GHANA
BUILDING
CODE
BUILDING AND CONSTRUCTION
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Foreword

The Ghana Standards Authority is the National Statutory Body responsible for the development and promulgation of Ghana Standards.

The Ghana Standards Authority is a member of the African Organization for Standardization (ARSO), the International Organization for Standardization (ISO) and an affiliate member of the International Electrotechnical Commission (IEC).

This Ghana Building Code (GhBC) GS 1207:2018 is a modified adoption of the International Building Code. It lays down the essential requirements that buildings must conform.

The Committee responsible for the adoption of this Code is the National Technical Committee on Ghana Building Code.

This is the 1st edition.

Users of this Code should note that the Code undergoes revision from time to time and any references to it statutorily imply its latest edition.
PREFACE

INTRODUCTION
The Ghana Building Code (GhBC) establishes minimum requirements for buildings using prescriptive and performance-related provisions. It is founded on broad-based principles that make possible the use of new materials and new building designs.

The Code is to ensure uniformity of standards for the regulation and compliance of stakeholders in the building construction industry in terms of public health, general safety, fire protection, structural efficiency and integrity, and environmental integrity and sustainability.


DEVELOPMENT
Historically, Building Regulations have been in use by various Municipal Administrations in Ghana from about the 1940s; and in 1960, the then West African Building Research Institute (WABRI) published, a Part III of a Code dealing with ‘Loads’ to be used in Civil Engineering Structures.

By the early 1970s the Code and Building Regulations that were hitherto in use were evidently out of date and the Building and Road Research Institute (BRRI) of the Council for Scientific and Industrial Research (CSIR) decided to produce a draft Building Code for discussion, modification and use as a basis for a final Building Code to address the redundancy of the earlier documents.

Further development by BRRI resulted in Parts 3 (Structural Loads & Procedures) and 4 (Foundations) of the Draft Code which was published in 1977. This was followed by the Parts 1 (Administration), 2 (Use & Occupancy) and 5 (Housing & Small Buildings) by 1988.

With changes in land use patterns, materials and construction methods and local government structure, the Ministry of Works and Housing had produced the National Building Regulations in 1996 which was gazetted as LI 1630 (1996).

Between 2011 and 2012, a Draft Ghana Building Code (2012) was compiled based on the BRRI Draft Building Code of 1988 under the auspices of the Ministry of Water Resources, Works and Housing (MWRWH) with funding from the UNDP, through the National Disaster Management Organization (NADMO).

This current Code which is the first comprehensive Building Code for Ghana, was undertaken by the Ghana Standards Authority (GSA), for and on the behalf of the Ministry of Works & Housing (MWH) with financial assistance by the Swiss Government through the International Finance Corporation / World Bank Group, Ghana Office (IFC/WBG).
MAINTENANCE

This Building Code will be kept up to date through the review of proposed changes that will be submitted by code enforcement officials, industry representatives, design professionals, government officials and other stakeholders.

The GSA will receive and compile comments from stakeholders yearly for review by a Code Review Committee. Proposed changes will be carefully considered through an open code development process in which all stakeholders may participate.

A new edition of this Code will be promulgated every 4 years.

The Code Development Process reflects principles of openness, transparency, balance, due process and consensus, as embodied in GS 1012 - Principles for Standardization and Procedures for Technical Work, which governs the Ghana Standard Development process.

ACKNOWLEDGEMENT

The development of this Code was undertaken by the Ghana Standards Authority (GSA), for and on behalf of the Ministry of Works & Housing (MWH). The support of the Swiss Government through the International Finance Corporation / World Bank Group, Ghana Office (IFC/WBG) is hereby appreciated and acknowledged.

Between 2011 and 2012, a Draft Ghana Building Code (2012) was compiled based on the BRRI Draft Building Code of 1988 under the auspices of the Ministry of Water Resources, Works and Housing (MWRWH) with funding from the UNDP, through the National Disaster Management Organization (NADMO). Ing. K. A. Solomon-Ayeh (then of the BRRI) was the special Consultant for the 2012 Draft Code.

The continuous support of the Ministry of Trade and Industry is acknowledged.

Ing. John A. Tettey of the Ministry of Works and Housing and his team are acknowledged for the 2012 Draft Code.

Dr. Ebenezer A. Tackie of the KNUST and his team are acknowledged for the final report of the Ghana Building Code 1989.

Dr. K. Amonoo-Neizer of the BRRI is acknowledged for the contribution to the 1977 and 1988 Draft Codes.
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<table>
<thead>
<tr>
<th>NO.</th>
<th>NAME</th>
<th>ORGANISATION</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
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</tr>
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</tr>
<tr>
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</tr>
</tbody>
</table>
Table of Contents

FOREWORD ............................................................................................................................. i

1. PREFACE ........................................................................................................................... ii
2. INTRODUCTION ................................................................................................................ ii
3. DEVELOPMENT ................................................................................................................ iii
4. ACKNOWLEDGEMENT ........................................................................................................ iv
5. GHANA BUILDING CODE (2018) TECHNICAL COMMITTEE ........................................... iv
6. PART 1: SCOPE AND ADMINISTRATION ........................................................................ 1
7. SCOPE AND APPLICATION ............................................................................................... 1
8. 1 GENERAL ......................................................................................................................... 1
9. 1.1 Title .............................................................................................................................. 1

10. 1.1.2 Scope ....................................................................................................................... 1

11. 1.1.4 Referenced Codes ...................................................................................................... 1
12. 1.1.4.1 Gas ........................................................................................................................ 1
13. 1.1.4.2 Mechanical .............................................................................................................. 1
14. 1.1.4.3 Plumbing ................................................................................................................ 1
15. 1.1.4.4 Property maintenance ............................................................................................ 2
16. 1.1.4.5 Fire prevention ....................................................................................................... 2
17. 1.1.4.6 Energy .................................................................................................................... 2
18. 1.1.4.7 Existing buildings .................................................................................................. 2
19. 1.2 APPLICABILITY ........................................................................................................... 2

20. 1.2.1 General ..................................................................................................................... 2

21. 1.2.2 Application of references ........................................................................................ 2
22. 1.2.3 Referenced Codes and standards .............................................................................. 2

23. 1.2.3.1 Conflicts ................................................................................................................ 2
24. 1.2.3.2 Provisions in referenced Codes and standards ....................................................... 2
25. 1.2.4 Partial invalidity ......................................................................................................... 2
26. 1.2.5 Existing structures ...................................................................................................... 2
27. 1.2.6 Buildings not previously occupied ......................................................................... 2
28. 1.2.7 Buildings previously occupied ................................................................................. 3
29. ADMINISTRATION AND ENFORCEMENT ...................................................................... 3

30. 1.3 BUILDING SAFETY .................................................................................................... 3
31. 1.3.1 Enforcement agency .................................................................................................. 3

32. 1.3.1.1 Appointment .......................................................................................................... 3
33. 1.3.1.2 Organization .......................................................................................................... 3
34. 1.3.1.3 Delegation of Powers ............................................................................................ 3
35. 1.3.1.4 Qualification of Head of Works ............................................................................. 3

36. 1.3.1.6 Qualifications of Building Assistant Supervisor .................................................. 3
37. 1.4 DUTIES AND POWERS OF HEAD OF WORKS ...................................................... 3

38. 1.4.1 General ..................................................................................................................... 3

39. 1.4.2 Applications and permits ........................................................................................ 3
40. 1.4.2.1 Determination of substantially improved or substantially damaged existing .... 3
41. 1.4.3 Notices and orders ..................................................................................................... 4

42. 1.4.4 Inspections ................................................................................................................ 4
43. 1.4.5 Identification ............................................................................................................. 4
44. 1.4.6 Right of entry ............................................................................................................ 4
45. 1.4.7 Department records .................................................................................................. 4

46. 1.4.8 Liability ..................................................................................................................... 4
47. 1.4.8.1 Legal defense .......................................................................................................... 4
48. 1.4.9 Approved materials and equipment ......................................................................... 4
49. 1.4.9.1 Used materials and equipment .............................................................................. 4

50. 1.4.10 Modifications .......................................................................................................... 4

51. 1.4.10.1 Flood hazard areas .............................................................................................. 5
52. 1.4.11 Alternative materials, design and methods of construction and equipment .......... 5

53. 1.4.11.1 Research reports ................................................................................................. 5

54. GS 1207: 2018
1.12.3.1 Footing and foundation inspection .................................................. 13
1.12.3.2 Concrete slab and under-floor inspection ........................................ 13
1.12.3.3 Lowest floor elevation ..................................................................... 13
1.12.3.4 Frame inspection .............................................................................. 13
1.12.3.5 Lath, gypsum board and gypsum panel product inspection ............... 14
1.12.3.6 Weather-exposed balcony and walking surface waterproofing .......... 14
1.12.3.7 Fire- and smoke-resistant penetrations .......................................... 14
1.12.3.8 Energy efficiency inspections ......................................................... 14
1.12.3.9 Other inspections ............................................................................ 14
1.12.3.10 Special inspections ....................................................................... 14
1.12.3.11 Final inspection ............................................................................ 14
1.12.3.11.1 Flood hazard documentation ..................................................... 14
1.12.4 Inspection agencies ............................................................................ 14
1.12.5 Inspection requests ............................................................................ 14
1.12.6 Approval required .............................................................................. 14
1.13 CERTIFICATE OF OCCUPANCY ............................................................ 15
1.13.1 Change of occupancy .............................................................. ........................ 15
1.13.2 Certificate issued .............................................................................. 15
1.13.3 Temporary occupancy ....................................................................... 15
1.13.4 Revocation ......................................................................................... 15
1.14 SERVICE UTILITIES.............................................................................. 15
1.14.1 Connection of service utilities ........................................................... 15
1.14.2 Temporary connection ...................................................................... 15
1.14.3 Authority to disconnect service utilities ........................................... 15
1.15 BOARD OF APPEALS ............................................................................ 16
1.15.1 General .............................................................................................. 16
1.15.2 Limitations on authority ................................................................. ........................ 16
1.15.3 Qualifications .................................................................................... 16
1.16 VIOLATIONS ......................................................................................... 16
1.16.1 Unlawful acts .................................................................................... 16
1.16.2 Notice of violation ............................................................................ 16
1.16.3 Prosecution of violation .................................................................... 16
1.16.4 Violation penalties ........................................................................... 16
1.17 STOP WORK ORDER ............................................................................ 17
1.17.1 Authority .......................................................................................... 17
1.17.2 Issuance ............................................................................................ 17
1.17.3 Unlawful continuance ...................................................................... 17
1.18 UNSAFE STRUCTURES AND EQUIPMENT ........................................ 17
1.18.1 Conditions ......................................................................................... 17
1.18.2 Record ............................................................................................... 17
1.18.3 Notice ................................................................................................. 17
1.18.4 Method of service ............................................................................ 17
1.18.5 Restoration ......................................................................................... 17
PART 2: DEFINITIONS ................................................................................. 18
2.1 GENERAL ............................................................................................. 18
2.1.1 Scope .................................................................................................. 18
2.1.2 Interchangeability ............................................................................. 18
2.1.3 Terms defined in other Codes ............................................................ 18
2.1.4 Terms not defined ............................................................................. 18
2.2 DEFINITIONS ........................................................................................ 18
PART 3: OCCUPANCY CLASSIFICATION AND USE .................................... 54
3.1 SCOPE .................................................................................................. 54
3.1.1 General ............................................................................................. 54
3.2 OCCUPANCY CLASSIFICATION AND USE DESIGNATION .................. 54
3.2.1 Occupancy classification .................................................................. 54
3.2.2 Use designation ................................................................................ 54
3.3 ASSEMBLY GROUP A ........................................................................... 54
3.3.1 Assembly Group A ........................................................................... 54
3.3.1.1 Small buildings and tenant spaces ............................................... 54
3.3.1.2 Small assembly spaces ................................................................. 54
3.3.1.3 Associated with Group E occupancies ....................................... 55
3.3.1.4 Accessory to places of religious worship. .................................................. 55
3.3.2 Assembly Group A-1. ................................................................. 55
3.3.3 Assembly Group A-2. ................................................................. 55
3.3.4 Assembly Group A-3. ................................................................. 55
3.3.5 Assembly Group A-4. ................................................................. 55
3.3.6 Assembly Group A-5. ................................................................. 55
3.4 BUSINESS GROUP B ................................................................. 55
3.4.1 Business Group B. ................................................................. 55
3.5 EDUCATIONAL GROUP E .......................................................... 56
3.5.1 Educational Group E. ............................................................... 56
3.5.1.1 Accessory to places of religious worship. ........................................... 56
3.5.2 Group E, day care facilities ......................................................... 56
3.5.2.1 Within places of religious worship. .................................................. 56
3.5.2.2 Five or fewer children ................................................................. 56
3.5.2.3 Five or fewer children in a dwelling unit ......................................... 56
3.6 FACTORY GROUP F ................................................................. 56
3.6.1 Factory Industrial Group F. ......................................................... 56
3.6.2 Moderate-hazard factory industrial, Group F-1 .................................... 56
3.6.3 Low-hazard factory industrial, Group F-2 ....................................... 57
3.7 HIGH-HAZARD GROUP H ............................................................ 57
3.7.1 High-hazard Group H ................................................................. 57
3.7.1.1 Uses other than Group H ............................................................. 62
3.7.2 Hazardous materials ................................................................. 62
3.7.3 High-hazard Group H-1 ............................................................... 62
3.7.3.1 Occupancies containing explosives not classified as H-1 .................. 63
3.7.4 High-hazard Group H-2 ............................................................... 63
3.7.5 High-hazard Group H-3 ............................................................... 63
3.7.6 High-hazard Group H-4 ............................................................... 63
3.7.7 High-hazard Group H-5 ............................................................... 63
3.7.8 Multiple hazards ................................................................. 63
3.8 INSTITUTIONAL GROUP I ........................................................... 64
3.8.1 Institutional Group I ................................................................. 64
3.8.2 Institutional Group I-1 ............................................................... 64
3.8.2.1 Condition 1. ................................................................. 64
3.8.2.2 Condition 2. ................................................................. 64
3.8.2.3 Six to 16 persons receiving custodial care. ....................................... 64
3.8.2.4 Five or fewer persons receiving custodial care. .................................. 64
3.8.3 Institutional Group I-2 ............................................................... 64
3.8.3.1 Occupancy conditions. ............................................................. 64
3.8.3.1.1 Condition 1. ................................................................. 64
3.8.3.1.2 Condition 2. ................................................................. 64
3.8.3.2 Five or fewer persons receiving medical care. ................................... 64
3.8.4 Institutional Group I-3 ............................................................... 65
3.8.4.1 Condition 1. ................................................................. 65
3.8.4.2 Condition 2. ................................................................. 65
3.8.4.3 Condition 3. ................................................................. 65
3.8.4.4 Condition 4. ................................................................. 65
3.8.4.5 Condition 5. ................................................................. 65
3.8.5 Institutional Group I-4, day care facilities ............................................ 65
3.8.5.1 Classification as Group E ......................................................... 65
3.8.5.2 Within a place of religious worship .............................................. 65
3.8.5.3 Five or fewer persons receiving care .............................................. 65
3.8.5.4 Five or fewer persons receiving care in a dwelling unit .................... 65
3.9 MERCANTILE GROUP M .......................................................... 66
3.9.1 Mercantile Group M ................................................................. 66
3.9.2 Quantity of hazardous materials ..................................................... 66
3.10 RESIDENTIAL GROUP R ......................................................... 66
3.10.1 Residential Group R ............................................................... 66
3.10.2 Residential Group R-1 ............................................................. 66
3.10.3 Residential Group R-2 ............................................................. 66
3.10.4 Residential Group R-3 ............................................................. 66
3.10.4.1 Care facilities within a dwelling..............................................................66
3.10.4.2 Lodging houses..........................................................66
3.10.5 Residential Group R-4..........................................................66
3.10.5.1 Condition 1..........................................................67
3.10.5.2 Condition 2..........................................................67
3.11 STORAGE GROUP S..........................................................67
3.11.1 Storage Group S..........................................................67
3.11.1.1 Accessory storage spaces........................................67
3.11.1.2 Moderate-hazard storage, Group S-1........................................67
3.11.1.3 Low-hazard storage, Group S-2........................................67
3.12 UTILITY AND MISCELLANEOUS GROUP U.......................................68
3.12.1 General..........................................................68
3.12.1.1 Greenhouses...................................................68
PART 4: SPECIAL DETAILED REQUIREMENTS BASED ON OCCUPANCY AND USE........69
4.1 SCOPE........................................................................69
4.1.1 Detailed occupancy and use requirements........................................69
4.2 COVERED MALL AND OPEN MALL BUILDINGS........................................69
4.2.1 Applicability..........................................................69
4.2.1.1 Open mall building perimeter line........................................69
4.2.2 Open space..........................................................69
4.2.3 Lease plan..........................................................69
4.2.4 Construction..........................................................69
4.2.4.1 Area and types of construction........................................70
4.2.4.1.1 Covered and open mall buildings.......................................70
4.2.4.1.2 Anchor buildings..................................................70
4.2.4.1.3 Parking garage..................................................70
4.2.4.2 Fire-resistance-rated separation........................................70
4.2.4.2.1 Tenant separations..................................................70
4.2.4.2.2 Anchor building separation........................................70
4.2.4.2.2.1 Openings between anchor building and mall......................70
4.2.4.2.3 Parking garages..................................................70
4.2.4.3 Open mall construction..................................................70
4.2.4.3.1 Pedestrian walkways..............................................71
4.2.5 Automatic sprinkler system..................................................71
4.2.6 Interior finishes and features..................................................71
4.2.6.1 Interior finish......................................................71
4.2.6.2 Kiosks..........................................................71
4.2.6.3 Children’s play structures..................................................71
4.2.6.4 Plastic signs..........................................................72
4.2.6.4.1 Area..............................................................72
4.2.6.4.2 Height and width......................................................72
4.2.6.4.3 Location..............................................................72
4.2.6.4.4 Plastics other than foam plastics......................................72
4.2.6.4.4.1 Encasement......................................................72
4.2.6.4.5 Foam plastics......................................................72
4.2.6.4.5.1 Density..............................................................72
4.2.6.4.5.2 Thickness..............................................................72
4.2.7 Emergency systems..........................................................72
4.2.7.1 Fire hydrant system......................................................72
4.2.7.2 Smoke control......................................................72
4.2.7.3 Emergency power......................................................72
4.2.7.4 Emergency voice/alarm communication system........................................72
4.2.7.5 Fire department access to equipment........................................73
4.2.8 Means of escape..........................................................73
4.2.8.1 Mall width..........................................................73
4.2.8.1.1 Minimum width......................................................73
4.2.8.2 Determination of occupant load........................................73
4.2.8.2.1 Occupant formula......................................................73
4.2.8.2.2 OLF range......................................................73
4.2.8.2.3 Anchor buildings......................................................73
4.2.8.2.4 Food courts......................................................73
4.2.8.3 Number of means of escape.

4.2.8.4 Arrangements of means of escape.

4.2.8.4.1 Anchor building means of escape.

4.2.8.5 Distance to exits.

4.2.8.6 Access to exits.

4.2.8.6.1 Exit passageways.

4.2.8.7 Service areas fronting on exit passageways.

4.2.8.8 Security grilles and doors.

4.3 HIGH-RISE BUILDINGS.

4.3.1 Applicability.

4.3.2 Construction.

4.3.2.1 Reduction in fire-resistance rating.

4.3.2.1.1 Type of construction.

4.3.2.1.2 Shaft enclosures.

4.3.2.2 Seismic considerations.

4.3.2.3 Structural integrity of interior exit stairways and elevator hoistway enclosures.

4.3.2.3.1 Wall assembly.

4.3.2.3.2 Wall assembly materials.

4.3.2.3.3 Concrete and masonry walls.

4.3.2.3.4 Other wall assemblies.

4.3.2.4 Sprayed fire-resistant materials (SFRM).

4.3.3 Automatic sprinkler system.

4.3.3.1 Number of sprinkler risers and system design.

4.3.3.1.1 Riser location.

4.3.3.2 Water supply to required fire pumps.

4.3.3.3 Secondary water supply.

4.3.3.4 Fire pump room.

4.3.4 Emergency systems.

4.3.4.1 Smoke detection.

4.3.4.2 Fire alarm system.

4.3.4.3 Fire hydrant system.

4.3.4.4 Emergency voice/alarm communication system.

4.3.4.5 Emergency responder radio coverage.

4.3.4.6 Fire command.

4.3.4.7 Smoke removal.

4.3.4.8 Standby and emergency power.

4.3.4.8.1 Equipment room.

4.3.4.8.2 Fuel line piping protection.

4.3.4.8.3 Standby power loads.

4.3.4.8.4 Emergency power loads.

4.3.5 Means of escape and evacuation.

4.3.5.1 Remoteness of interior exit stairways.

4.3.5.2 Additional interior exit stairway.

4.3.5.3 Stairway door operation.

4.3.5.3.1 Stairway communication system.

4.3.5.4 Smokeproof enclosures.

4.3.5.5 Luminous escape path markings.

4.3.5.6 Emergency escape and rescue.

4.3.6 Elevators.

4.3.6.1 Fire service access elevator.

4.3.6.2 Occupant evacuation elevators.

4.4 ATRIUMS.

4.4.1 General.

4.4.2 Use.

4.4.3 Automatic sprinkler protection.

4.4.4 Fire alarm system.

4.4.5 Smoke control.

4.4.6 Enclosure of atriums.

4.4.7 Standby power.

4.4.8 Interior finish.

4.4.9 Exit access travel distance.
4.4.2.5 Sleeping rooms ........................................ 83
4.4.2.6 Fuel dispensing ........................................ 83
4.4.2.7 Mixed occupancies and uses .......................... 83
4.4.2.8 Equipment and appliances ............................ 83
4.4.2.8.1 Elevation of ignition sources ..................... 83
4.4.2.8.1.1 Parking garages .................................. 83
4.4.2.8.2 Public garages ...................................... 83
4.4.2.8.3 Private garages ...................................... 83
4.4.3 Private garages and carports ............................ 84
4.4.3.1 Classification .......................................... 84
4.4.3.2 Separation ............................................. 84
4.4.3.2.2 Ducts ................................................ 84
4.4.3.3 Carports ............................................... 84
4.4.3.3.1 Carport separation ................................ 84
4.4.4 Public parking garages ................................... 84
4.4.4.1 Guards ............................................... 84
4.4.4.2 Vehicle barriers ...................................... 84
4.4.4.3 Ramps .................................................. 84
4.4.5 Open parking garages .................................... 84
4.4.5.1 Construction .......................................... 84
4.4.5.2 Openings ............................................. 84
4.4.5.2.1 Openings below grade ............................ 85
4.4.5.3 Mixed occupancies and uses ........................ 85
4.4.5.4 Area and height ...................................... 85
4.4.5.4.1 Single use ......................................... 85
4.4.5.5 Area and height increases ............................ 85
4.4.5.6 Fire separation distance .............................. 86
4.4.5.7 Means of escape ...................................... 86
4.4.5.8 Fire hydrant system .................................. 86
4.4.5.9 Enclosure of vertical openings ....................... 86
4.4.5.10 Ventilation ........................................... 86
4.4.5.11 Prohibitions .......................................... 86
4.6.6 Enclosed parking garages ................................................................. 86
4.6.6.1 Heights and areas ........................................................................ 86
4.6.6.2 Ventilation .................................................................................. 86
4.6.6.3 Automatic sprinkler system ........................................................... 86
4.6.7 Motor fuel-dispensing facilities ......................................................... 86
4.6.7.2 Canopies ...................................................................................... 87
4.6.7.2.1 Canopies used to support gaseous hydrogen systems .......... 87
4.6.8 Repair garages ................................................................................ 87
4.6.8.1 Ventilation .................................................................................. 87
4.6.8.2 Gas detection system .................................................................... 87
4.6.8.2.1 System activation ..................................................................... 87
4.6.8.2.2 Failure of the gas detection system ......................................... 88
4.7 GROUP I-2 ...................................................................................... 88
4.7.1 General .......................................................................................... 88
4.7.2 Corridors continuity and separation ................................................ 88
4.7.2.1 Waiting and similar areas ............................................................ 88
4.7.2.2 Care providers’ stations ............................................................... 88
4.7.2.3 Psychiatric treatment areas ........................................................ 88
4.7.2.4 Gift shops .................................................................................. 88
4.7.2.5 Nursing home housing units ....................................................... 89
4.7.2.6 Nursing home cooking facilities ............................................... 89
4.7.3 Corridor wall construction .............................................................. 89
4.7.3.1 Corridor doors .......................................................................... 89
4.7.4 Means of escape ............................................................................ 90
4.7.4.1 Direct access to a corridor .......................................................... 90
4.7.4.1.1 Locking devices ................................................................... 90
4.7.4.2 Distance of travel ....................................................................... 90
4.7.4.3 Projections in nursing home corridors ....................................... 90
4.7.4.4 Group I-2 care suites ................................................................. 90
4.7.4.4.1 Exit access through care suites ............................................ 90
4.7.4.4.2 Separation ............................................................................. 90
4.7.4.4.3 Access to corridor ................................................................. 90
4.7.4.4.4 Doors within care suites ........................................................ 91
4.7.4.4.5 Care suites containing sleeping room areas ......................... 91
4.7.4.4.5.1 Area ............................................................................... 91
4.7.4.4.5.2 Exit access ....................................................................... 91
4.7.4.4.6 Care suites not containing sleeping rooms ......................... 91
4.7.4.4.6.1 Area ............................................................................... 91
4.7.4.4.6.2 Exit access ....................................................................... 91
4.7.5 Smoke barriers ............................................................................ 91
4.7.5.1 Smoke compartment size .......................................................... 91
4.7.5.2 Exit access travel distance ........................................................ 92
4.7.5.3 Refuge area ............................................................................... 92
4.7.5.4 Independent escape ................................................................. 92
4.7.5.5 Horizontal assemblies ............................................................... 92
4.7.6 Automatic-closing doors ............................................................... 92
4.7.7 Automatic sprinkler system ........................................................... 92
4.7.8 Fire alarm system .......................................................................... 92
4.7.10 Secured yards ........................................................................... 92
4.7.11 Electrical systems ........................................................................ 93
4.8 GROUP I-3 .................................................................................... 93
4.8.1 General ....................................................................................... 93
4.8.2 Other occupancies ........................................................................ 93
4.8.3 Means of escape .......................................................................... 93
4.8.3.1 Door width ............................................................................... 93
4.8.3.2 Sliding doors ........................................................................... 93
4.8.3.3 Guard tower doors ................................................................. 93
4.8.3.4 Spiral stairways ....................................................................... 93
4.8.3.5 Ships ladders ............................................................................. 93
4.8.3.6 Exit discharge .......................................................................... 93
4.10.7 Fire hydrant .................................................................................................................. 100
4.11 SPECIAL AMUSEMENT BUILDINGS ............................................................................. 100
4.11.1 General ......................................................................................................................... 100
4.11.2 Automatic fire detection ............................................................................................. 100
4.11.3 Automatic sprinkler system ....................................................................................... 100
4.11.4 Alarm ........................................................................................................................... 100
4.11.5 Emergency voice/alarm communications system ...................................................... 100
4.11.6 Exit marking ................................................................................................................. 101
4.11.6.1 Photoluminescent exit signs .................................................................................. 101
4.11.7 Interior finish ............................................................................................................... 101
4.12 AIRCRAFT-RELATED OCCUPANCIES ......................................................................... 101
4.12.1 General ......................................................................................................................... 101
4.12.2 Airport traffic control towers ..................................................................................... 101
4.12.2.1 Construction ........................................................................................................... 101
4.12.2.1.1 Type of construction ......................................................................................... 101
4.12.2.1.2 Structural integrity of interior exit stairways and elevator hoistway ................. 101
4.12.2.1.3 Sprayed fire-resistant materials (SFRM). ........................................................... 101
4.12.2.2 Means of escape and evacuation .......................................................................... 101
4.12.2.2.1 Stairways ............................................................................................................ 102
4.12.2.2.2 Exit access .......................................................................................................... 102
4.12.2.2.3 Number of exits ............................................................................................... 102
4.12.2.2.3.1 Interior finish .................................................................................................. 102
4.12.2.2.3.2 Exit separation ............................................................................................... 102
4.12.2.3 Emergency systems ............................................................................................... 102
4.12.2.3.1 Automatic smoke detection systems ................................................................. 102
4.12.2.3.2 Fire command center ....................................................................................... 102
4.12.2.3.3 Smoke removal ................................................................................................... 102
4.12.2.4 Automatic sprinkler system ................................................................................... 102
4.12.2.4.1 Fire pump room ............................................................................................... 103
4.12.2.5 Protection of elevator wiring and cables ................................................................. 103
4.12.2.5.1 Elevators for occupant evacuation .................................................................. 103
4.12.2.6 Accessibility ............................................................................................................ 103
4.12.3 Aircraft hangars .......................................................................................................... 103
4.12.3.1 Exterior walls ......................................................................................................... 103
4.12.3.2 Basements ............................................................................................................. 103
4.12.3.3 Floor surface .......................................................................................................... 103
4.12.3.4 Heating equipment ............................................................................................... 103
4.12.3.5 Finishing ................................................................................................................ 103
4.12.3.6 Fire suppression .................................................................................................... 103
4.12.3.6.1 Hazardous operations ...................................................................................... 104
4.12.3.6.2 Separation of maximum single fire areas .......................................................... 104
4.12.4 Residential aircraft hangars ....................................................................................... 105
4.12.4.1 Fire separation ....................................................................................................... 105
4.12.4.2 Escape .................................................................................................................... 105
4.12.4.3 Smoke alarms ........................................................................................................ 105
4.12.4.4 Independent systems .............................................................................................. 105
4.12.4.5 Height and area limits ............................................................................................ 105
4.12.5 Aircraft paint hangars ................................................................................................. 105
4.12.5.1 Occupancy classification ..................................................................................... 105
4.12.5.2 Construction ......................................................................................................... 105
4.12.5.3 Spray equipment cleaning operations ................................................................. 105
4.12.5.4 Operations .............................................................................................................. 105
4.12.5.5 Storage ................................................................................................................... 105
4.12.5.6 Fire suppression ..................................................................................................... 105
4.12.5.7 Ventilation ............................................................................................................. 105
4.12.5.8 Electrical ................................................................................................................ 105
4.12.5.8.1 Class I, Division 1 hazardous locations ............................................................ 106
4.12.5.8.2 Class I, Division 2 hazardous locations ............................................................ 106
4.12.6 Heliports and helistops .............................................................................................. 106
4.12.6.1 Size ......................................................................................................................... 106
4.12.6.2 Design .................................................................................................................... 106
4.12.6.3 Means of escape ........................................................................................................ 106
4.12.6.4 Rooftop heliports and helistops ............................................................................. 106
4.12.6.5 Fire hydrant system .................................................................................................. 106
4.13 COMBUSTIBLE STORAGE .............................................................................................. 106
4.13.1 General ........................................................................................................................ 106
4.13.2 Attic, under-floor and concealed spaces ...................................................................... 106
4.14 HAZARDOUS MATERIALS ............................................................................................. 106
4.14.1 General ........................................................................................................................ 106
4.14.1.1 Other provisions ......................................................................................................... 106
4.14.1.2 Materials .................................................................................................................... 107
4.14.1.2.1 Aerosol products .................................................................................................... 107
4.14.1.3 Information required .................................................................................................. 107
4.14.2 Control areas ............................................................................................................... 107
4.14.2.1 Construction requirements ....................................................................................... 107
4.14.2.2 Percentage of maximum allowable quantities .......................................................... 107
4.14.2.3 Number ..................................................................................................................... 108
4.14.2.4 Fire-resistance rating requirements ......................................................................... 108
4.14.2.5 Hazardous material in Group M display and storage areas and in Group S .......... 108
4.14.2.5.1 Nonflammable solids and nonflammable and noncombustible liquids .............. 109
4.14.2.5.2 Flammable and combustible liquids ................................................................. 109
4.14.2.5.3 Aerosol products .................................................................................................. 109
4.14.3 Ventilation .................................................................................................................. 109
4.14.4 Hazardous material systems ....................................................................................... 109
4.14.5 Inside storage, dispensing and use ............................................................................. 109
4.14.5.1 Explosion control ..................................................................................................... 109
4.14.5.2 Emergency or standby power ................................................................................ 111
4.14.5.2.1 Exempt applications ............................................................................................ 111
4.14.5.2.2 Fail-safe engineered systems ............................................................................. 111
4.14.5.3 Spill control, drainage and containment ................................................................. 111
4.14.6 Outdoor storage, dispensing and use ......................................................................... 111
4.14.6.1 Weather protection .................................................................................................. 111
4.14.6.1.1 Walls .................................................................................................................... 111
4.14.6.1.2 Separation distance .............................................................................................. 111
4.14.6.1.3 Noncombustible construction ............................................................................. 111
4.15 GROUPS H-1, H-2, H-3, H-4 AND H-5 ........................................................................... 111
4.15.1 General ........................................................................................................................ 111
4.15.2 Compliance ................................................................................................................. 111
4.15.3 Automatic fire detection systems .............................................................................. 111
4.15.4 Automatic sprinkler system ....................................................................................... 112
4.15.5 Emergency alarms ....................................................................................................... 112
4.15.5.1 Storage ..................................................................................................................... 112
4.15.5.2 Dispensing, use and handling ................................................................................ 112
4.15.5.3 Supervision .............................................................................................................. 112
4.15.5.4 Emergency alarm systems ..................................................................................... 112
4.15.6 Fire separation distance .............................................................................................. 112
4.15.6.1 Group H occupancy minimum fire separation distance ......................................... 112
4.15.6.1.1 Group H-1 ........................................................................................................... 112
4.15.6.1.2 Group H-2 ........................................................................................................... 113
4.15.6.1.3 Groups H-2 and H-3 .......................................................................................... 113
4.15.6.1.4 Explosive materials ............................................................................................. 113
4.15.6.2 Detached buildings for Group H-1, H-2 or H-3 occupancy .................................... 113
4.15.6.2.1 Wall and opening protection ............................................................................... 113
4.15.7 Special provisions for Group H-1 occupancies ............................................................ 113
4.15.7.1 Floors in storage rooms .......................................................................................... 114
4.15.8 Special provisions for Group H-2 and H-3 occupancies .............................................. 114
4.15.8.1 Multiple hazards ...................................................................................................... 114
4.15.8.2 Separation of incompatible materials .................................................................... 114
4.15.8.3 Water reactives ........................................................................................................ 114
4.15.8.4 Floors in storage rooms .......................................................................................... 114
4.15.8.5 Waterproof room ..................................................................................................... 114
4.15.9 Group H-2 .................................................................................................................... 114
4.15.9.1 Flammable and combustible liquids. ................................................................. 114
4.15.9.1.1 Mixed occupancies. .................................................................................. 114
4.15.9.1.1.1 Height exception. ................................................................................ 114
4.15.9.1.2 Tank protection. ..................................................................................... 115
4.15.9.1.3 Tanks. ...................................................................................................... 115
4.15.9.1.4 Leakage containment. .............................................................................. 115
4.15.9.1.5 Leakage alarm. ....................................................................................... 115
4.15.9.1.6 Tank vent. ............................................................................................... 115
4.15.9.1.7 Room ventilation. ................................................................................... 115
4.15.9.1.8 Explosion venting. .................................................................................. 115
4.15.9.1.9 Tank openings other than vents. ............................................................... 115
4.15.9.2 Liquefied petroleum gas facilities. ................................................................. 115
4.15.9.3 Dry cleaning plants. .................................................................................... 115
4.15.10 Groups H-3 and H-4. ....................................................................................... 115
4.15.10.1 Flammable and combustible liquids. .............................................................. 115
4.15.10.2 Gas rooms. ................................................................................................ 115
4.15.10.3 Floors in storage rooms. ............................................................................. 115
4.15.10.4 Separation of highly toxic solids and liquids. .............................................. 115
4.15.11 Group H-5. ..................................................................................................... 116
4.15.11.1 Fabrication areas. ...................................................................................... 116
4.15.11.1.1 Hazardous materials. ........................................................................... 116
4.15.11.1.1.1 Aggregate quantities. ....................................................................... 116
4.15.11.1.2 Hazardous production materials. ........................................................... 118
4.15.11.1.2 Separation. ............................................................................................ 118
4.15.11.1.3 Location of occupied levels. .................................................................. 118
4.15.11.1.4 Floors. .................................................................................................. 118
4.15.11.1.5 Shafts and openings through floors. ....................................................... 118
4.15.11.1.6 Ventilation. .......................................................................................... 118
4.15.11.1.7 Transporting hazardous production materials to fabrication areas. .... 119
4.15.11.1.8 Electrical. ............................................................................................. 119
4.15.11.1.8.1 Workstations. .................................................................................. 119
4.15.11.1.2 Corridors. ............................................................................................. 119
4.15.11.1.3 Service corridors. ................................................................................ 119
4.15.11.1.3.1 Use conditions. ................................................................................ 119
4.15.11.1.3.2 Mechanical ventilation. .................................................................... 119
4.15.11.1.3.3 Means of escape. ............................................................................. 119
4.15.11.1.3.4 Minimum width. ............................................................................... 120
4.15.11.1.3.5 Emergency alarm system. ................................................................ 120
4.15.11.1.3.5.1 Service corridors .......................................................................... 120
4.15.11.1.3.5.2 Corridors and interior exit stairways and ramps. ......................... 120
4.15.11.1.3.5.3 Liquid storage rooms, HPM rooms and gas rooms. .................... 120
4.15.11.1.3.5.4 Alarm-initiating devices. ................................................................. 120
4.15.11.1.3.5.5 Alarm signals. ................................................................................ 120
4.15.11.1.4 Storage of hazardous production materials. ......................................... 120
4.15.11.1.5 HPM rooms, gas rooms, liquid storage room construction. ................. 120
4.15.11.1.5.1 HPM rooms and gas rooms. .............................................................. 120
4.15.11.1.5.2 Liquid storage rooms. ..................................................................... 120
4.15.11.1.5.3 Floors. .............................................................................................. 121
4.15.11.1.5.4 Location. .......................................................................................... 121
4.15.11.1.5.5 Explosion control. ........................................................................... 121
4.15.11.1.5.6 Exits. ................................................................................................ 121
4.15.11.1.5.7 Doors ............................................................................................... 121
4.15.11.1.5.8 Ventilation. ....................................................................................... 121
4.15.11.1.5.9 Emergency alarm system. ................................................................. 121
4.15.11.1.6 Piping and tubing. ................................................................................ 121
4.15.11.1.6.1 HPM having a health-hazard ranking of 3 or 4. ............................. 121
4.15.11.1.6.2 Location in service corridors. ........................................................... 121
4.15.11.1.6.3 Excess flow control. ......................................................................... 121
4.15.11.1.6.4 Installations in corridors and above other occupancies. ................. 121
4.15.11.1.6.5 Identification. ................................................................................... 122
4.15.11.1.7 Gas detection systems. ......................................................................... 122
4.15.11.7.1 Where required: ................................................................. 122
4.15.11.7.1.1 Fabrication areas .......................................................... 122
4.15.11.7.1.2 HPM rooms ................................................................. 122
4.15.11.7.1.3 Gas cabinets, exhausted enclosures and gas rooms ......... 122
4.15.11.7.1.4 Corridors ................................................................. 122
4.15.11.7.2 Gas detection system operation ....................................... 122
4.15.11.7.2.1 Alarms ................................................................. 123
4.15.11.7.2.2 Shutoff of gas supply .................................................. 123
4.15.11.8 Manual fire alarm system .................................................... 123
4.15.11.9 Emergency control station .................................................. 123
4.15.11.9.1 Location ........................................................................... 123
4.15.11.9.2 Staffing ................................................................. 123
4.15.11.9.3 Signals ........................................................................ 123
4.15.11.10 Emergency power system ................................................. 124
4.15.11.10.1 Required electrical systems ............................................ 124
4.15.11.10.2 Exhaust ventilation systems ............................................ 124
4.15.11.11 Automatic sprinkler system protection in exhaust ducts for HPM ................................................................. 124
4.15.11.11.1 Metallic and noncombustible nonmetallic exhaust ducts .................................................................................. 124
4.15.11.11.2 Combustible nonmetallic exhaust ducts ............................ 124
4.15.11.11.3 Automatic sprinkler locations ........................................ 125
4.16 SPRAY APPLICATION OF FLAMMABLE FINISHES ......................... 125
4.16.1 General ................................................................. 125
4.16.2 Spray rooms ................................................................. 125
4.16.2.1 Construction ................................................................. 125
4.16.2.2 Surfaces ................................................................. 125
4.16.2.3 Ventilation ................................................................. 125
4.16.3 Spraying spaces ................................................................. 125
4.16.3.1 Surfaces ................................................................. 125
4.16.4 Spray booths ........................................................................ 125
4.16.5 Fire protection ................................................................. 125
4.17 DRYING ROOMS ................................................................. 125
4.17.1 General ................................................................. 125
4.17.2 Piping clearance ................................................................. 125
4.17.3 Insulation ................................................................. 125
4.17.4 Fire protection ................................................................. 126
4.18 ORGANIC COATINGS ................................................................. 126
4.18.1 Building features ................................................................. 126
4.18.2 Location ................................................................. 126
4.18.3 Process mills ................................................................. 126
4.18.4 Tank storage ................................................................. 126
4.18.5 Nitrocellulose storage ............................................................ 126
4.18.6 Finished products ................................................................. 126
4.19 LIVE/WORK UNITS ................................................................. 126
4.19.1 General ................................................................. 126
4.19.1.1 Limitations ................................................................. 126
4.19.2 Occupancies ................................................................. 126
4.19.3 Means of escape ................................................................. 126
4.19.3.1 Escape capacity ............................................................. 127
4.19.3.2 Spiral stairways .............................................................. 127
4.19.4 Vertical openings ................................................................. 127
4.19.5 Fire protection ................................................................. 127
4.19.6 Structural ................................................................. 127
4.19.7 Accessibility ................................................................. 127
4.19.8 Ventilation ................................................................. 127
4.19.9 Plumbing facilities ................................................................. 127
4.20 GROUPS I-1, R-1, R-2, R-3 AND R-4 ............................................ 127
4.20.1 General ................................................................. 127
4.20.2 Separation walls ................................................................. 127
4.20.3 Horizontal separation ............................................................. 127
4.20.4 Automatic sprinkler system .................................................... 127
4.20.5 Fire alarm systems and smoke alarms ....................................... 127
4.20.6 Smoke barriers in Group I-1, Condition 2. ............................................. 128
4.20.6.1 Refuge area. ...................................................................................... 128
4.20.7 Group I-1 assisted living housing units. ................................................. 128
4.20.8 Group I-1 cooking facilities. ................................................................... 128
4.20.8.1 Cooking facilities open to the corridor. ............................................. 129
4.20.9 Group R cooking facilities. ..................................................................... 129
4.20.10 Group R-2 dormitory cooking facilities. ............................................... 129
4.20.10.1 Cooking appliances. ......................................................................... 129
4.20.10.2 Cooking appliances in sleeping rooms. ............................................ 129
4.21 HYDROGEN FUEL GAS ROOMS ............................................................. 129
4.21.1 General. ............................................................................................. 129
4.21.2 Location. ............................................................................................ 129
4.21.3 Design and construction. ....................................................................... 129
4.21.3.1 Pressure control. .............................................................................. 129
4.21.3.2 Windows ......................................................................................... 129
4.21.4 Exhaust ventilation. .............................................................................. 129
4.21.5 Gas detection system. ........................................................................... 129
4.21.5.1 System activation. ........................................................................... 129
4.21.5.2 Failure of the gas detection system. ............................................... 130
4.21.6 Explosion control. ................................................................................ 130
4.21.7 Standby power. .................................................................................... 130
4.22 AMBULATORY CARE FACILITIES ......................................................... 130
4.22.1 General. ............................................................................................. 130
4.22.2 Separation. .......................................................................................... 130
4.22.3 Smoke compartments. ......................................................................... 130
4.22.3.1 Means of escape ........................................................................... 130
4.22.3.2 Refuge area. ................................................................................... 130
4.22.3.3 Independent escape. ....................................................................... 130
4.22.4 Automatic sprinkler systems. ................................................................. 130
4.22.5 Fire alarm systems. ............................................................................. 130
4.22.6 Electrical systems. ................................................................................ 130
4.23 STORM SHELTERS ................................................................................ 131
4.23.1 General. ............................................................................................. 131
4.23.2 Construction. ...................................................................................... 131
4.23.3 Critical emergency operations. ............................................................... 131
4.23.4 Group E occupancies .......................................................................... 131
4.23.4.1 Required occupant capacity ............................................................. 131
4.23.4.2 Location ......................................................................................... 131
4.24 CHILDREN’S PLAY STRUCTURES ......................................................... 131
4.24.1 General. ............................................................................................. 131
4.24.2 Materials. ........................................................................................... 131
4.24.3 Fire protection. .................................................................................... 132
4.24.4 Separation. .......................................................................................... 132
4.24.5 Area limits. .......................................................................................... 132
4.25 HYPERBARIC FACILITIES ................................................................... 132
4.25.1 Hyperbaric facilities. ........................................................................... 132
4.26 COMBUSTIBLE DUSTS, GRAIN PROCESSING AND STORAGE ........... 132
4.26.1 General. ............................................................................................. 132
4.26.1.1 Type of construction and height exceptions. .................................... 132
4.26.1.2 Grinding rooms .............................................................................. 132
4.26.1.3 Conveyors. ..................................................................................... 133
4.26.1.4 Explosion control ........................................................................... 133
4.26.1.5 Grain elevators. .............................................................................. 133
4.26.1.6 Coal pockets. .................................................................................. 133
4.26.1.7 Tire rebuilding. ............................................................................... 133
4.27 MEDICAL GAS SYSTEMS .................................................................... 133
4.27.1 General. ............................................................................................. 133
4.27.2 Interior supply location. ........................................................................ 133
4.27.2.1 One-hour exterior room. ................................................................... 133
4.27.2.2 One-hour interior room. ................................................................. 134
4.27.2.3 Gas cabinets. .................................................................................. 134
5.6.4 Exemption to Open Air Space

5.6.2.6 Joint Open Air Space

5.6.2.4 The front open space would govern the height of the building (see 6.5.4).

5.6.2.1.3 Side Open Space

5.6.2.1 Exterior open Spaces

5.5 REQUIREMENTS OF PLOTS

5.5.7.1 Residential

5.5.7.2 Industrial

5.5.7.3 Other Land uses

5.5.7.3.1 Assembly Halls/Cinema Theatres

5.5.7.3.2 Fuel/Gas filling Station

5.6 OPEN SPACES (WITHIN A PLOT)

5.6.1 General

5.6.1.2 Open spaces separate for each building of wing –

5.6.2 Residential Buildings

5.6.2.1 Exterior open Spaces

5.6.2.1.1 Front Open Space

5.6.2.1.2 Rear Open Space

5.6.2.1.3 Side Open Space

5.6.2.3.2 For tower-like structures, as an alternative to 5.6.2.3., open spaces shall be as below:

5.6.2.4 The front open space would govern the height of the building (see 6.5.4)

5.6.2.5 Interior Open Spaces

5.6.2.6 Joint Open Air Space –

5.6.3 Other Occupancies

5.6.3.1 Open spaces for other occupancies shall be as below:

5.6.4 Exemption to Open Spaces

5.6.4.1 Projections into Open Spaces –

PART 5: SITE DEVELOPMENT AND LAND USE

5.1 GENERAL

5.2 LAND USE CLASSIFICATION AND USES PERMITTED

5.3 MEANS OF ACCESS

5.3.1 Every building/plot shall abut on a public/private means of access like streets/roads duly formed.

5.3.2 - Pathways

5.3.3 Width of Means of Access

5.3.3.1 Other Buildings

5.3.5 Access from Highways/Important Roads

5.3.6 For high rise buildings and buildings other than residential, the following additional provisions of means of access shall be ensured:

5.4 COMMUNITY OPEN/SOCIAL SPACES AND AMENITIES

5.4.1 Residential and Commercial Zones

5.4.4 Industrial Zones

5.4.5 Other Amenities

5.4.6 Underground cisterns for water storage

5.4.7 Size of Plots

5.5 REQUIREMENTS OF PLOTS

5.5.1 Uses as Specifically Designated on Development Plan

5.5.2.1.2 Uses to be in Conformity with the Zone

5.5.2.1.3 Uses

5.5.3.1 Residential

5.5.3.2 - Pathways

5.5.4 Distance from Electric Lines

5.5.5 Distance from Electric Lines

5.5.6 InterClause of Roads

5.5.7.1 Residential

5.5.7.2 Industrial

5.5.7.3 Other Land uses

5.5.7.3.1 Assembly Halls/Cinema Theatres

5.5.7.3.2 Fuel/Gas filling Station

5.6 OPEN SPACES (WITHIN A PLOT)

5.6.1 General

5.6.1.2 Open spaces separate for each building of wing –

5.6.2 Residential Buildings

5.6.2.1 Exterior open Spaces

5.6.2.1.1 Front Open Space

5.6.2.1.2 Rear Open Space

5.6.2.1.3 Side Open Space

5.6.2.3.2 For tower-like structures, as an alternative to 5.6.2.3., open spaces shall be as below:

5.6.2.4 The front open space would govern the height of the building (see 6.5.4)

5.6.2.5 Interior Open Spaces

5.6.2.6 Joint Open Air Space –

5.6.3 Other Occupancies

5.6.3.1 Open spaces for other occupancies shall be as below:

5.6.4 Exemption to Open Spaces

5.6.4.1 Projections into Open Spaces –

5.6.5.1 Uses to be in Conformity with the Zone

5.6.5.2.1 Uses

5.6.5.3 Other Land uses

5.6.5.3.1 Assembly Halls/Cinema Theatres

5.6.5.3.2 Fuel/Gas filling Station

5.7 OPEN SPACES (WITHIN A PLOT)

5.7.1 Residential

5.7.2 Industrial

5.7.3 Other Land uses

5.7.3.1 Assembly Halls/Cinema Theatres

5.7.3.2 Fuel/Gas filling Station

5.8 OPEN SPACES (WITHIN A PLOT)

5.8.1 General

5.8.1.2 Open spaces separate for each building of wing –

5.8.2 Residential Buildings

5.8.2.1 Exterior open Spaces

5.8.2.1.1 Front Open Space

5.8.2.1.2 Rear Open Space

5.8.2.1.3 Side Open Space

5.8.2.3.2 For tower-like structures, as an alternative to 5.8.2.3., open spaces shall be as below:

5.8.2.4 The front open space would govern the height of the building (see 6.5.4)

5.8.2.5 Interior Open Spaces

5.8.2.6 Joint Open Air Space –

5.8.3 Other Occupancies

5.8.3.1 Open spaces for other occupancies shall be as below:

5.8.4 Exemption to Open Spaces

5.8.4.1 Projections into Open Spaces –
5.13.2 Vegetation and soil protection.

5.13.1.6 Documentation.

5.13.1.4.2 Restoration.

5.13.1.4 Soil reuse and restoration.

5.12.2.3 Signage.

5.12.2.2 Recirculation.

5.12.1.1 Water for outdoor landscape irrigation.

5.11.1.2 Adjoining plots and property.

5.11.1.1 Increased runoff.

5.11.1 Stormwater management.

5.11.1.1 Increased runoff.

5.11.1.2 Adjoining plots and property.

5.11.1.3 Brownfields.

5.11.2 Coal tar sealants.

5.12 LANDSCAPE IRRIGATION AND OUTDOOR FOUNTAINS

5.12.1 Landscape irrigation systems.

5.12.1.1 Water for outdoor landscape irrigation.

5.12.1.2 Irrigation system design and installation.

5.12.2.1 Treatment.

5.12.2.2 Recirculation.

5.12.2.3 Signage.

5.12.3 Signage.

5.11 STORMWATER MANAGEMENT

5.10.7 Greenfield sites.

5.10.6 Agricultural land.

5.10.5 Conservation area.

5.10.4 Wetland protection.

5.10.3 Surface water protection.

5.10.2.3 Development in flood hazard areas.

5.10.2.2 Flood hazard area preservation, specific.

5.10.2.1 Flood hazard area preservation, general.

5.10.2 Flood hazard areas.

5.10.1 PRESERVATION OF NATURAL RESOURCES

5.10.7.1 Site disturbance limits on greenfield sites.

5.10.7 Greenfield sites.

5.10.6 Agricultural land.

5.10.5 Conservation area.

5.10.4 Wetland protection.

5.10.3 Surface water protection.

5.10.2.3 Development in flood hazard areas.

5.10.2.2 Flood hazard area preservation, specific.

5.10.2.1 Flood hazard area preservation, general.

5.10.2 Flood hazard areas.

5.10.1 PRESERVATION OF NATURAL RESOURCES

5.9 PREDESIGN SITE INVENTORY AND ASSESSMENT.

5.8 GREENBELTS AND LANDSCAPING

5.8.1 General.

APPENDIX B

OFF-STREET PARKING SPACES

APPENDIX D

D-2 PLANNING

D-2.1 Type of Development – The type of development for low income housing shall be plotted development as row housing/flatted development as row housing/block development as group housing.

D-2.2 Density – The maximum density, in dwelling units/hectare, shall be as given in Table 4.9.

D-2.3 Size of Plot/Plinth Area – The minimum plot size shall be as follows, with coverage not exceeding 75 percent.

The maximum density, in dwelling units/hectare, shall be as given in Table 4.9.
5.13.2.2 Invasive plant species .......................................................... 160
5.14 BUILDING SITE WASTE MANAGEMENT ..................................... 160
5.14.1 Building site waste management plan ........................................ 160
5.14.2 Construction waste ............................................................... 161
5.15 TRANSPORTATION IMPACT ....................................................... 161
5.15.1 Walkways and bicycle paths ..................................................... 161
5.15.2 Changing and shower facilities ................................................ 161
5.15.3 Bicycle parking and storage ..................................................... 161
5.15.3.1 Short-term bicycle parking .................................................. 163
5.15.3.2 Long-term bicycle parking ................................................... 163
5.15.7.4 Preferred vehicle parking ..................................................... 163
5.15.4.1 High-occupancy vehicle parking ........................................... 164
5.15.4.2 Low-emission, hybrid, and electric vehicle parking ................. 164
5.16 HEAT ISLAND MITIGATION ....................................................... 164
5.16.1 General ................................................................................. 164
5.16.2 Site hardscape ....................................................................... 164
5.16.2.1 Site hardscape materials ....................................................... 164
5.16.2.2 Shading by structures ........................................................... 164
5.16.2.3 Shading by trees .................................................................. 164
5.16.2.4 Pervious pavement and permeable unit pavement .................. 165
5.16.3 Roof surfaces ...................................................................... 165
5.16.3.1 Roof coverings—solar reflectance and thermal emittance ........ 165
TABLE 5.16.3.1 ............................................................................. 165
5.16.3.1.1 Roof products testing ......................................................... 165
5.16.3.1.2 Solar reflectance index ....................................................... 165
5.16.3.2 Vegetative roofs ................................................................. 166
5.17 SITE LIGHTING ........................................................................ 166
5.17.1 Light pollution control .............................................................. 166
5.17.1.1 Lighting pollution zones ....................................................... 167
TABLE 5.17.1.1 ............................................................................. 167
5.17.2 Uplight .................................................................................. 167
Table 5.17.3(2) .............................................................................. 168
PART 6: GENERAL BUILDING HEIGHTS AND AREAS .................... 169
6.1 GENERA ................................................................................... 169
6.1 Scope ......................................................................................... 169
6.2 BUILDING ADDRESS ................................................................. 169
6.2.1 Address identification .............................................................. 169
6.3 GENERAL BUILDING HEIGHT AND AREA LIMITATIONS .......... 169
6.3.1 General .................................................................................. 169
6.3.1.1 Special industrial occupancies ................................................. 169
6.3.1.2 Buildings on same plot .......................................................... 169
6.3.1.3 Type I construction ............................................................... 169
6.3.1.4 Occupied roofs ..................................................................... 169
6.3.1.4.1 Enclosures over occupied roof areas ................................. 170
6.4 BUILDING HEIGHT AND NUMBER OF STORIES .................... 170
6.4.1 General .................................................................................. 170
6.4.1.1 Unlimited area buildings ....................................................... 170
6.4.1.2 Special provisions ................................................................. 170
6.4.2 Mixed occupancy ..................................................................... 170
6.4.3 Height in feet ......................................................................... 170
TABLE 6.4.3 .................................................................................... 171
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE 
5.174
6.4.4 Number of stories ................................................................. 171
TABLE 6.4.4 ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE a, b ...................................................... 172
TABLE 6.4.4—continued ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE a, b .......................... 173
6.5 AREA AND HEIGHT LIMITATIONS ............................................. 173
6.5.1 General .................................................................................. 173
6.5.2.1 Unlimited Areas .................................................................. 174
6.5.3 Street Width ............................................................................ 174
6.5.4 Height Limit ............................................................................ 174
6.5.4.2 Height Exceptions ................................................................. 174
6.5.4.2.1 Roof Structures

TABLE 6.5.1 - Comparative Floor Area Ratios for Occupancies Facing one Public Street of at Least 9m Width

6.5.5 Restrictions in the vicinity of Aerodromes

Table 6.5.2 - Floor Area Ratio and Coverage for Group Housing

6.6 REQUIREMENTS OF PARTS OF BUILDINGS

6.6.1 Plinth

6.6.1.1 Main Buildings

6.6.1.2 Interior Courtyards

6.6.2 Habitable Rooms

6.6.2.1 Height

6.6.2.2 Size

6.6.3 Kitchen

6.6.3.1 Height

6.6.3.2 Size

6.6.3.3 Other Requirements

6.6.4 Bathrooms and Water-Closets

6.6.4.1 Height

6.6.4.2 Size

6.6.4.3 Other Requirements

6.6.5 Ledge or Loft

6.6.5.1 Height

6.6.5.2 Size

6.6.5.3 Loft

6.6.6 Mezzanine floor

6.6.6.1 Height

6.6.6.2 Size

6.6.6.3 Other Requirements

6.6.7 Store Room

6.6.7.1 Height

6.6.7.2 Size

6.6.8 Garage

6.6.8.1 Height

6.6.8.2 Size

6.6.9 Basement

6.6.9.3 The basement shall have the following requirements

6.6.10 Chimneys

6.6.11 Parapet

6.6.12 Cabin

6.6.13 Boundary Wall

6.6.13.1 The requirements of the boundary wall are given below:

6.6.14 Wells

6.6.14.1 Location

6.6.14.2 Requirements

6.6.15 Septic Tanks

6.6.15.1 Location of Septic Tanks and Subsurface Absorption Systems

6.6.15.2 Requirements

6.6.16 Office-cum-Letter Box Room

6.6.16.1 Business Building

6.6.17 Meter Rooms

6.6.18 Staircase

6.6.18.1.1 Minimum Width

6.6.18.1.2 Minimum Tread

6.6.18.1.3 Maximum Riser

6.6.18.2 Minimum headroom

6.6.19 Roofs

6.6.21 Special requirements for the physically handicapped

6.7 RODENT-PROOFING AND TERMITE-PROOFING OF BUILDINGS

APPENDIX A

A-0 GENERAL

A-0.1.1 Aerodrome Reference Point (ARP)
A-0.1.2 Approach Funnel

A-0.1.3 Elevation or Reduced Level

A-0.1.4 Transitional Area

A-1 PROHIBITED AREA

A-1.2 For the Aerodromes listed by the Ghana Civil Aviation Authority

A-2 HEIGHT RESTRICTION

A-2.1 For the aerodromes listed by the Ghana Civil Aviation Authority

Table 4.5 - Height Restriction with respect to Approach Funnels

A-3 AERODROMES

6.8 MEZZANINES AND EQUIPMENT PLATFORMS

6.8.1 General

6.8.2 Mezzanines

6.8.2.1 Area limitation

6.8.2.1.1 Aggregate area of mezzanines and equipment platforms

6.8.2.2 Means of escape

6.8.2.3 Openness

6.8.3 Equipment platforms

6.8.3.1 Area limitation

6.8.3.2 Automatic sprinkler system

6.8.3.3 Guards

6.9 BUILDING AREA

6.9.1 General

6.9.1.1 Unlimited area buildings

6.9.1.2 Special provisions

6.9.1.3 Basements

6.9.2 Allowable area determination

TABLE 6.9.2

6.9.2.1 Single-occupancy, one-storey buildings

6.9.2.2 Mixed-occupancy, one-storey buildings

6.9.2.2.1 Group H-2 or H-3 mixed occupancies

6.9.2.3 Single-occupancy, multistorey buildings

6.9.2.4 Mixed-occupancy, multistorey buildings

6.9.2.4.1 Group H-2 or H-3 mixed occupancies

6.9.3 Frontage increase

6.9.3.1 Minimum percentage of perimeter

6.9.3.2 Minimum frontage distance

6.9.3.3 Amount of increase

6.10 UNLIMITED AREA BUILDINGS

6.10.1 General

6.10.1.1 Accessory occupancies

6.10.2 Measurement of open spaces

6.10.2.1 Reduced open space

6.10.3 Nonsprinklered, one-storey buildings

6.10.4 Sprinklered, one-storey buildings

6.10.4.1 Mixed occupancy buildings with Groups A-1 and A-2

6.10.5 Two-storey buildings

6.10.6 Group A-3 buildings of Type II construction

6.10.7 Group A-3 buildings of Type III and IV construction

6.10.8 Group H-2, H-3 and H-4 occupancies

6.10.8.1 Allowable area

6.10.8.1.2 Liquid storage rooms

6.10.8.1.3 Spray paint booths

6.10.8.2 Located on building perimeter

6.10.8.3 Occupancy separations

6.10.8.4 Height limitations

6.10.9 Unlimited mixed occupancy buildings with Group H-5

6.10.10 Aircraft paint hangar

6.10.11 Group E buildings

6.10.12 Motion picture theaters

6.11 MIXED USE AND OCCUPANCY

6.11.2 Accessory occupancies
7.2.4.1 Fire

7.2.3 Type II.

7.2.1 General.

TABLE 7.2: FIRE
7.2.4.2 Cross-laminated timber in exterior walls ................................................................. 206
7.2.4.3 Exterior structural members ..................................................................................... 206
7.3 COMBUSTIBLE MATERIAL IN TYPES I AND II CONSTRUCTION ........................... 206
7.3.1 Allowable materials ............................................................................................... 206
7.3.1.1 Ducts ................................................................................................................. 208
7.3.1.2 Piping ................................................................................................................. 208
7.3.1.3 Electrical ............................................................................................................ 208
PART 8: FIRE AND SMOKE PROTECTION FEATURES ..................................................... 209
8.1 GENERAL .................................................................................................................... 209
8.1.1 Scope ..................................................................................................................... 209
8.2 MULTIPLE USE FIRE ASSEMBLIES ....................................................................... 209
8.2.1 Multiple use fire assemblies ............................................................................... 209
8.3 FIRE-RESISTANCE RATINGS AND FIRE TESTS ................................................... 209
8.3.1 Scope ..................................................................................................................... 209
8.3.2 Fire-resistance ratings .......................................................................................... 209
8.3.2.1 Nonsymmetrical wall construction ................................................................... 209
8.3.2.2 Combustible components .................................................................................. 209
8.3.2.3 Restrained classification ..................................................................................... 209
8.3.2.4 Supplemental features ....................................................................................... 209
8.3.2.5 Exterior bearing walls ......................................................................................... 209
8.3.3 Methods for determining fire resistance ................................................................. 210
8.3.4 Automatic sprinklers ............................................................................................. 210
8.3.5 Noncombustibility tests ........................................................................................ 210
8.3.6 Fire-resistance-rated glazing ................................................................................ 210
8.3.7 Marking and identification ...................................................................................... 210
8.4 FIRE-RESISTANCE RATING OF STRUCTURAL MEMBERS ................................. 211
8.4.1 Requirements ........................................................................................................ 211
8.4.2 Column protection ................................................................................................. 211
8.4.3 Protection of the primary structural frame other than columns ......................... 211
8.4.4 Protection of secondary members ......................................................................... 211
8.4.4.1 Light-frame construction ................................................................................... 211
8.4.4.2 Horizontal assemblies ....................................................................................... 211
8.4.5 Truss protection ..................................................................................................... 211
8.4.6 Attachments to structural members ........................................................................ 211
8.4.7 Reinforcing ............................................................................................................ 211
8.4.8 Embedments and enclosures .................................................................................. 212
8.4.9 Impact protection ................................................................................................... 212
8.4.10 Exterior structural members ................................................................................. 212
8.4.11 Bottom flange protection ....................................................................................... 212
8.4.12 Seismic isolation systems ...................................................................................... 212
8.4.13 Sprayed fire-resistant materials (SFRM) ............................................................... 212
8.4.13.1 Fire-resistance rating ......................................................................................... 212
8.4.13.2 Manufacturer’s installation instructions ........................................................... 212
8.4.13.3 Substrate condition ........................................................................................... 213
8.4.13.3.1 Surface conditions ......................................................................................... 213
8.4.13.3.2 Primers, paints and encapsulants ................................................................. 213
8.4.13.4 Temperature ..................................................................................................... 213
8.4.13.5 Finished condition ............................................................................................ 213
8.5 EXTERIOR WALLS ..................................................................................................... 213
8.5.1 General .................................................................................................................. 213
8.5.2 Projections ............................................................................................................. 213
8.5.2.1 Types I construction .......................................................................................... 213
8.5.2.2 Type II, III or IV construction ......................................................................... 214
8.5.2.3 Combustible projections ..................................................................................... 214
8.5.2.3.1 Balconies and similar projections ................................................................. 214
8.5.2.4 Bay and oriel windows ....................................................................................... 214
8.5.3 Buildings on the same plot ..................................................................................... 214
8.5.4 Materials ................................................................................................................. 215
8.5.6 Structural stability .................................................................................................. 215
8.5.7 Unexposed surface temperature .......................................................................... 215
TABLE 8.5.8 MAXIMUM AREA OF EXTERIOR WALL OPENINGS BASED ON FIRE 216
8.8.6 Openings
8.8.5 Exterior walls
8.8.4 Mixed openings
8.8.3 Unprotected openings
8.8.2 Protected openings
8.8.1 Allowable area of openings
8.7.9 Voids at interclauses
8.7.7 Penetrations
8.7.6 Openings
8.7.5 Vertical separation of openings
8.7.4 Exterior walls
8.7.3.10 Fire areas
8.7.3.9 Separated occupancies
8.7.3.8 Control areas
8.7.3.7 Incidental uses
8.7.3.6 Atriums
8.7.3.5 Horizontal exit
8.7.3.4 Exit passageway
8.7.3.3 Enclosures for exit access stairways
8.7.3.2 Interior exit stairway and ramp construction
8.7.3.1 Shaft enclosures
8.7.3 Fire-resistance rating
8.7.2 Materials
8.7.1 General
8.6.10 Joints
8.6.9 Penetrations
8.6.8 Openings
8.6.7 Combustible framing in fire walls
8.6.6 Vertical continuity
8.6.5.2 Horizontal projecting elements
8.6.5.1 Exterior walls
8.6.5 Horizontal continuity
8.6.4 Fire-resistance rating
8.6.3 Materials
8.6.2 Buildings with sloped roofs
8.6.1 Stepped buildings
8.6. Fire WALLS
8.5.8.6 Vertical exposure
8.5.8.5 Exterior walls
8.5.8.4 Mixed openings
8.5.8.3 Unprotected openings
8.5.8.2 Protected openings
8.5.8.1 Allowable area of openings
8.5.7.10 Ducts and air transfer openings
8.5.7.11 Parapets
8.5.7 Exterior walls
8.5.6.11 Ducts and air transfer openings
8.5.6.10 Joints
8.5.6.9 Penetrations
8.5.6.8 Openings
8.5.6 Combustible framing in fire walls
8.5.5.8.6 Vertical exposure
8.5.5.8.5 Exterior walls
8.5.5.8.4 Mixed openings
8.5.5.8.3 Unprotected openings
8.5.5.8.2 Protected openings
8.5.5.8.1 Allowable area of openings
8.5.5.7 Penetrations
8.5.5.6 Openings
8.5.5.5 Exterior walls
8.5.5.4 Structural stability
8.5.5.3 Enclosures for exit access stairways
8.5.5.2 Horizontal projecting elements
8.5.5.1 Exterior walls
8.5.5.4 Structural stability
8.5.5.3 Enclosures for exit access stairways
8.5.5.2 Horizontal projecting elements
8.5.5.1 Exterior walls
8.5.4 Penetrations
8.5.3.10 Fire areas
8.5.3.9 Separated occupancies
8.5.3.8 Control areas
8.5.3.7 Incidental uses
8.5.3.6 Atriums
8.5.3.5 Horizontal exit
8.5.3.4 Exit passageway
8.5.3.3 Enclosures for exit access stairways
8.5.3.2 Interior exit stairway and ramp construction
8.5.3.1 Shaft enclosures
8.5.3 Fire-resistance rating
8.5.2 Materials
8.5.1 General
8.4.10 Joints
8.4.9 Penetrations
8.4.8 Openings
8.4.7 Combustible framing in fire walls
8.4.6 Vertical continuity
8.4.5 Horizontal projecting elements
8.4.4 Structural stability
8.4.3 Fire-resistance rating
8.4.2 Materials
8.4.1 General
8.3.7 Prohibited penetrations
8.3.6 Atriums
8.3.5 Horizontal exit
8.3.4 Exit passageway
8.3.3 Enclosures for exit access stairways
8.3.2 Interior exit stairway and ramp construction
8.3.1 Shaft enclosures
8.3 Fire-resistance rating
8.2.6 Openings
8.2.5 Exterior walls
8.2.4 Structural stability
8.2.3 Materials
8.2.2 Materials
8.2.1 General
8.1.10 Joints
8.1.9 Penetrations
8.1.8 Openings
8.1.7 Combustible framing in fire walls
8.1.6 Vertical continuity
8.1.5 Horizontal projecting elements
8.1.4 Structural stability
8.1.3 Fire-resistance rating
8.1.2 Materials
8.1.1 General
8.7.3.10 FIRE-RESISTANCE RATING REQUIREMENTS FOR FIRE BARRIERS, FIRE WALLS OR HORIZONTAL ASSEMBLIES BETWEEN FIRE AREAS
8.12.1 General.
8.12.2 Individual dwelling unit.
8.12.3 Opening size.
8.12.4 Continuity.
8.12.5 Joint.
8.12.6 Ducts and air transfer openings.
8.12.7 Atriums.

8.11.2.4.3 Dwelling units and sleeping units.
8.11.2.4.4 Separating smoke compartments.
8.11.2.4.5 Separating incidental uses.
8.11.2.4 Fire.
8.11.2.3 Supporting construction.
8.11.2.2 Smoke and draft control doors.
8.11.2.2.1 Smoke and draft control door labeling.
8.11.2.2.2 Self- or automatic-closing doors.
8.11.2 Penetrations.
8.11.1 Joints.

8.10.7 Joints.
8.10.6 Penetrations.
8.10.5 Openings.
8.10.4 Continuity.
8.10.3 Fire.
8.10.2 Materials.
8.10.1 General.

8.9.4.1 Separating mixed occupancies.
8.9.4.2 Separating fire areas.
8.9.4.3 Dwelling units and sleeping units.
8.9.4.4 Separating smoke compartments.
8.9.4.5 Separating incidental uses.
8.9.4.6 Other separations.
8.9.2 Materials.
8.9.1 General.

8.9.3 Fire-resistance rating.
8.9.2 Continuity.
8.9.1 Materials.

8.8.8 Joints.
8.8.7 Penetrations.

8.7 Joints.
8.6 Penetrations.
8.5 Openings.
8.4 Continuity.
8.3 Fire.
8.2 Materials.
8.1 General.

8.6.9 Ducts and air transfer openings.
8.6.8 Joints.
8.6.7 Penetrations.
8.6.6 Penetrations.
8.6.5 Penetrations.
8.6.4 Penetrations.
8.6.3 Penetrations.
8.6.2 Penetrations.
8.6.1 Penetrations.

8.5.1 Group F-1 and ambulatory care facilities.
8.5 Openings.
8.4 Continuity.
8.3 Fire.
8.2 Materials.
8.1 General.

8.4.1 Separating mixed occupancies.
8.4.2 Separating fire areas.
8.4.3 Dwelling units and sleeping units.
8.4.4 Separating smoke compartments.
8.4.5 Separating incidental uses.
8.4.6 Other separations.
8.3.2 Continuity.
8.3.1 Materials.
8.3 General.

8.3.7 Joints.
8.3.6 Penetrations.
8.3.5 Penetrations.
8.3.4 Penetrations.
8.3.3 Penetrations.
8.3.2 Penetrations.
8.3.1 Penetrations.
8.3 General.

8.2.7 Joints.
8.2.6 Penetrations.
8.2.5 Penetrations.
8.2.4 Penetrations.
8.2.3 Penetrations.
8.2.2 Penetrations.
8.2.1 Penetrations.
8.2 General.

8.1.5 Joints.
8.1.4 Penetrations.
8.1.3 Penetrations.
8.1.2 Penetrations.
8.1.1 Penetrations.
8.1 General.

8.11 FLOOR AND ROOF ASSEMBLIES.
8.11.1 General.
8.11.2 Horizontal assemblies.
8.11.2.1 Materials.
8.11.2.2 Continuity.
8.11.2.3 Supporting construction.
8.11.2.4 Fire-resistance rating.
8.11.2.4.1 Separating mixed occupancies.
8.11.2.4.2 Separating fire areas.
8.11.2.4.3 Dwelling units and sleeping units.
8.11.2.4.4 Separating smoke compartments.
8.11.2.4.5 Separating incidental uses.
8.11.2.4.6 Other separations.
8.11.2.5 Ceiling panels.
8.11.2.6 Unusable space.
8.11.3 Nonfire-resistance-rated floor and roof assemblies.
8.11.3.1 Materials.
8.11.3.2 Continuity.
8.11.2 Vertical openings.
8.11.1 General.
8.11.1.1 Shaft enclosures.
8.11.1.2 Individual dwelling unit.
8.11.1.3 Escalator openings.
8.11.1.3.1 Opening size.
8.11.1.3.2 Automatic shutters.
8.11.1.4 Penetrations.
8.11.1.5 Joints.
8.11.1.5.1 Joints.
8.11.1.5.2 Joints.
8.11.1.6 Ducts and air transfer openings.
8.11.1.7 Atriums.
8.11.1.8 Masonry chimney.
8.12.1.10 Parking garages ................................................................. 232
8.12.1.10.1 Automobile ramps ..................................................... 232
8.12.1.10.2 Elevators ................................................................. 232
8.12.1.10.3 Duct systems .......................................................... 232
8.12.1.11 Mezzanine ................................................................. 232
8.12.1.12 Exit access stairways and ramps .................................... 232
8.12.1.13 Openings ................................................................. 233
8.12.1.13.1 Horizontal fire door assemblies .................................... 233
8.12.1.13.2 Access doors ........................................................ 233
8.12.1.14 Group I-3 ................................................................. 233
8.12.1.15 Skylights ........................................................................ 233
8.12.1.16 Openings otherwise permitted ....................................... 233
8.13 SHAFT ENCLOSURES ......................................................... 233
8.13.1 General .............................................................................. 233
8.13.2 Construction ................................................................. 233
8.13.3 Materials .......................................................................... 233
8.13.4 Fire-resistance rating ....................................................... 233
8.13.5 Continuity .......................................................................... 233
8.13.6 Exterior walls .................................................................... 234
8.13.7 Openings .......................................................................... 234
8.13.7.1 Prohibited openings ...................................................... 234
8.13.8 Penetrations ...................................................................... 234
8.13.8.1 Prohibited penetrations ............................................... 234
8.13.9 Joints ................................................................................ 234
8.13.10 Duct and air transfer openings ......................................... 234
8.13.11 Enclosure at the bottom .................................................. 235
8.13.12 Enclosure at top ............................................................. 235
8.13.13 Waste and linen chutes and incinerator rooms ................. 235
8.13.13.1 Waste and linen .......................................................... 235
8.13.13.2 Materials ..................................................................... 235
8.13.13.3 Chute access rooms ..................................................... 235
8.13.13.4 Chute discharge room ................................................... 235
8.13.13.5 Incinerator room .......................................................... 235
8.13.13.6 Automatic sprinkler system .......................................... 235
8.13.14 Elevator, dumbwaiter and other hoistways ....................... 235
8.14 PENETRATIONS ................................................................. 235
8.14.1 Scope ................................................................................. 235
8.14.1.1 Ducts and air transfer openings ..................................... 236
8.14.2 Installation .......................................................................... 236
8.14.3 Installation details ............................................................ 236
8.14.4 Fire-resistance-rated walls ................................................. 236
8.14.4.1 Through penetrations .................................................... 236
8.14.4.1.1 Fire-resistance-rated assemblies ................................ 236
8.14.4.1.2 Through-penetration firestop system ......................... 236
8.14.4.2 Membrane penetrations ............................................... 236
8.14.4.3 Dissimilar materials ..................................................... 237
8.14.5 Horizontal assemblies ...................................................... 237
8.14.5.1 Through penetrations .................................................... 237
8.14.5.1.1 Fire-resistance-rated assemblies ................................ 238
8.14.5.1.2 Through-penetration firestop system ......................... 238
8.14.5.2 Membrane penetrations ............................................... 238
8.14.5.3 Dissimilar materials ..................................................... 239
8.14.5.4 Penetrations in smoke barriers ....................................... 239
8.14.6 Nonfire-resistance-rated assemblies .................................. 239
8.14.6.1 Noncombustible penetrating items ................................ 239
8.14.6.2 Penetrating items .......................................................... 239
8.15 FIRE-RESISTANT JOINT SYSTEMS ................................... 239
8.15.1 General .............................................................................. 239
8.15.1.1 Curtain wall assembly ................................................... 240
8.15.2 Installation ......................................................................... 240
8.15.3 Fire test criteria .............................................................. 240
8.16.3.1 Testing requirements.
8.16.2.9.4 Fire door frame labeling requirements.
8.16.2.9.3 Smoke and draft control door labeling requirements.
8.16.2.9.2 Oversized doors.
8.16.2.9.1.1 Light kits, louvers and components.
8.16.2.8.2 Oversized doors.
8.16.2.8.1 Rolling fire shutters.
8.16.2.7.1 Labeled protective assemblies.
8.16.2.7.2 Fire door labeling requirements.
8.16.2.7.1.1 Light kits, louvers and components.
8.16.2.6.2 Oversized doors.
8.16.2.5.4 Fire door frames with transom lights and sidelights in corridors and smoke barriers.
8.16.2.5.3 Fire door frames with transom lights and sidelights in corridors and smoke barriers.
8.16.2.5.2 Elevator, stairway and ramp protectives.
8.16.2.5.1.2.2 Fire resistance-rated glazing in transom lights and sidelights in corridors and smoke barriers.
8.16.2.5.1.2.1 Horizontal exits.
8.16.2.5.1.2 Fire-protection-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.
8.16.2.5.1.1 Fire-resistance-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.
8.16.2.5.1.2 Fire-protection-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.
8.16.2.5.1 Fire-resistance-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.
8.16.2.5.1 Fire-resistance-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.
8.16.2.5.1 Fire-door hardware and closures.
8.16.2.4 Fire door frames.
8.16.2.3 Glazing in fire door assemblies.
8.16.2.2.5 Size limitations.
8.16.2.2.4 Fire-rated glazing that exceeds the Code requirements.
8.16.2.2.3 Fire-resistance-rated glazing identification.
8.16.2.2.2 Fire-protection-rated glazing identification.
8.16.2.2.1 Fire-rated glazing identification.
8.16.2.2 Marking fire-rated glazing assemblies.
8.16.2.1 Safety glazing.
8.16.2.1 Glazing.
8.16.2 Fire door assemblies.
8.16.2.1 Testing requirements.
8.16.2.1.1 Side-hinged or pivoted swinging doors.
8.16.2.1.2 Other types of assemblies.
8.16.2.1.3 Glazing in transom lights and sidelights in corridors and smoke barriers.
8.16.2.1.4 Smoke and draft control.
8.16.2.2 Performance requirements.
8.16.2.2.1 Door assemblies in corridors and smoke barriers.
8.16.2.2.1.1 Smoke and draft control.
8.16.2.2.2 Door assemblies in other fire partitions.
8.16.2.2.3 Doors in interior exit stairways and ramps and exit passageways.
8.16.2.2.3.1 Glazing in doors.
8.16.2.2.3 Fire doors.
8.16.2.1.1 Exterior curtain wall/nonfire-resistance-rated floor assembly interclauses.
8.16.2.1.2 Exterior curtain wall/vertical fire barrier interclauses.
8.16.2.1.4 Exterior curtain wall/floor interclause.
8.18.2.1.4 Fireblocking integrity.
8.18.2.1.1 Batts or blankets of mineral wool or mineral fiber.
8.18.2.1.2 Unfaced fiberglass.
8.18.2.1.3 Loose-fill insulation material.
8.18.2.1.4 Fireblocking integrity.

8.17.2.1 Smoke control system.
8.17.2.1.1 Ducts that penetrate fire-resistance-rated assemblies without dampers.
8.17.2.1.2 Ducts that penetrate nonfire-resistance-rated assemblies.
8.17.2.2 Hazardous exhaust ducts.
8.17.3 Damper testing, ratings and actuation.
8.17.3.1 Damper testing.
8.17.3.2 Damper rating.
8.17.3.2.1 Fire damper ratings.
8.17.3.2.2 Smoke damper ratings.
8.17.3.2.3 Combination fire/smoke damper ratings.
8.17.3.2.4 Corridor damper ratings.
8.17.3.3 Damper actuation.
8.17.3.3.1 Fire damper actuation device.
8.17.3.3.2 Smoke damper actuation.
8.17.3.3.3 Combination fire/smoke damper actuation.
8.17.3.3.4 Ceiling radiation damper actuation.
8.17.3.3.5 Corridor damper actuation.
8.17.4 Access and identification.
8.17.5 Where required.
8.17.5.1 Fire walls.
8.17.5.1.1 Horizontal exits.
8.17.5.2 Fire barriers.
8.17.5.2.1 Horizontal exits.
8.17.5.3 Shaft enclosures.
8.17.5.4.1 Corridors.
8.17.5.6 Exterior walls.
8.17.5.7 Smoke partitions.
8.17.6 Horizontal assemblies.
8.17.6.1 Through penetrations.
8.17.6.2 Membrane penetrations.
8.17.6.2.1 Ceiling radiation dampers testing and installation.
8.17.6.3 Nonfire-resistance-rated floor assemblies.
8.17.7 Flexible ducts and air connectors.
8.18 CONCEALED SPACES.
8.18.1 General.
8.18.2 Fireblocking.
8.18.2.1 Fireblocking materials.
8.18.2.1.1 Batts or blankets of mineral wool or mineral fiber.
8.18.2.1.2 Unfaced fiberglass.
8.18.2.1.3 Loose-fill insulation material.
8.18.2.1.4 Fireblocking integrity.
8.18.2.1.5 Double stud walls ................................................................. 258
8.18.2.2 Concealed wall spaces .......................................................... 258
8.18.2.3 Connections between horizontal and vertical spaces ................. 258
8.18.2.4 Stairways ............................................................................. 258
8.18.2.5 Ceiling and floor openings ....................................................... 258
8.18.2.6 Exterior wall coverings ........................................................... 258
8.18.2.7 Concealed sleeper spaces ....................................................... 259
8.18.3 Draftstopping in floors ............................................................... 259
8.18.3.1 Draftstopping materials ......................................................... 259
8.18.4 Draftstopping in attics ............................................................... 259
8.18.4.1 Draftstopping materials ......................................................... 259
8.18.4.1.1 Openings ........................................................................ 260
8.18.5 Combustible materials in concealed spaces in Type I or II construction 260
8.19 FIRE-RESISTANCE REQUIREMENTS FOR PLASTER ..................... 260
8.19.1 Thickness of plaster .................................................................. 260
8.19.2 Plaster equivalents .................................................................... 260
8.19.3 Noncombustible furring ............................................................ 260
8.19.4 Double reinforcement ................................................................ 260
8.19.5 Plaster alternatives for concrete ................................................ 260
8.20 THERMAL- AND SOUND-INSULATING MATERIALS ......................... 260
8.20.1 General ................................................................................. 260
8.20.2 Concealed installation ............................................................... 261
8.20.2.1 Facings ............................................................................. 261
8.20.3 Exposed installation .................................................................. 261
8.20.3.1 Attic floors ........................................................................ 261
8.20.4 Loose-fill insulation ................................................................. 261
8.21 PRESCRIPTIVE FIRE RESISTANCE ............................................. 262
8.22 CALCULATED FIRE RESISTANCE .............................................. 287
8.22.1 General ................................................................................. 287
8.22.2 Concrete assemblies ................................................................. 287
8.22.2.1 Concrete walls .................................................................... 287
8.22.2.1.1 Cast-in-place or precast walls ........................................... 287
8.22.2.1.1.1 Hollow-core precast wall panels .................................. 288
8.22.2.1.1.2 Core spaces filled ........................................................ 288
8.22.2.1.1.3 Tapered cross clauses .................................................. 288
8.22.2.1.1.4 Ribbed or undulating surfaces ...................................... 288
8.22.2.1.2 Multiwythe walls ............................................................. 288
8.22.2.1.2.1 Foam plastic insulation ............................................... 289
8.22.2.1.2.3 Joints between precast wall panels ................................ 289
8.22.2.1.3.1 Ceramic fiber joint protection ........................................ 289
8.22.2.1.4 Walls with gypsum wallboard or plaster finishes ............... 290
8.22.2.1.4.1 Nonfire-exposed side ................................................... 291
8.22.2.1.4.2 Fire-exposed side ........................................................ 292
8.22.2.1.4.3 Nonsymmetrical assemblies ........................................ 292
8.22.2.1.4.4 Minimum concrete fire-resistance rating ....................... 292
8.22.2.1.4.5 Concrete finishes ......................................................... 292
8.22.2.2 Concrete floor and roof slabs ................................................ 292
8.22.2.2.1 Reinforced and prestressed floors and roofs ....................... 292
8.22.2.2.1.1 Hollow-core prestressed slabs ...................................... 292
8.22.2.2.1.2 Slabs with sloping soffits .............................................. 292
8.22.2.2.1.3 Slabs with ribbed soffits .............................................. 293
8.22.2.2.2 Multicourse floors .......................................................... 293
8.22.2.2.3 Multicourse roofs ........................................................... 293
8.22.2.2.3.1 Heat transfer ............................................................... 294
8.22.2.2.4 Joints in precast slabs ....................................................... 294
8.22.2.3 Concrete cover over reinforcement ......................................... 294
8.22.2.3.1 Slab cover ..................................................................... 297
8.22.2.3.2 Reinforced beam cover ................................................... 297
8.22.2.3.3 Prestressed beam cover .................................................. 297
8.22.2.3.3.1 Calculating concrete cover ........................................... 298

xxvii
8.22.2.4 Concrete columns .......................................................... 298
8.22.2.4.1 Minimum size ......................................................... 298
8.22.2.4.1.1 Concrete strength less than or equal to 12,000 psi ................................................. 298
8.22.2.4.1.2 Concrete strength greater than 12,000 psi .......................................................... 298
8.22.2.4.2 Minimum cover for R/C columns ......................................... 298
8.22.2.4.3 Tie and spiral reinforcement ........................................... 298
8.22.2.4.4 Columns built into walls ............................................. 299
8.22.2.4.5 Precast cover units for steel columns .................................. 299
8.22.3 Concrete masonry ............................................................ 299
8.22.3.1 Equivalent thickness ....................................................... 299
8.22.3.1.1 Concrete masonry unit plus finishes .................................................. 299
8.22.3.1.2 Ungrouted or partially grouted construction .................................................. 299
8.22.3.1.3 Solid grouted construction .............................................. 299
8.22.3.1.4 Airspaces and cells filled with loose-fill material ............................................ 299
8.22.3.2 Concrete masonry walls ................................................... 299
8.22.3.2.1 Finish on nonfire-exposed side ........................................ 300
8.22.3.2.2 Finish on fire-exposed side .......................................... 300
8.22.3.2.3 Nonсимmetrical assemblies .......................................... 300
8.22.3.2.4 Minimum concrete masonry fire-resistance rating ......................... 300
8.22.3.2.5 Attachment of finishes ............................................... 300
8.22.3.3 Multiwythe masonry walls ............................................. 301
8.22.3.4 Concrete masonry lintels ................................................ 301
8.22.3.5 Concrete masonry columns ............................................. 301
8.22.4 Clay brick and tile masonry ................................................ 301
8.22.4.1 Masonry walls ............................................................ 301
8.22.4.1.1 Equivalent thickness .................................................. 303
8.22.4.1.1.1 Hollow clay units ..................................................... 303
8.22.4.1.1.2 Solid grouted clay units ........................................... 303
8.22.4.1.1.3 Units with filled cores ............................................. 303
8.22.4.1.1.4 Nonсимmetrical assemblies ........................................ 304
8.22.4.2 Multiwythe walls ........................................................ 304
8.22.4.2.1 Multiwythe walls of different material ........................................ 304
8.22.4.3 Reinforced clay masonry lintels ........................................ 304
8.22.4.4 Reinforced clay masonry columns ..................................... 304
8.22.5 Steel assemblies .............................................................. 304
8.22.5.1 Structural steel columns .................................................. 304
8.22.5.1.1 General ................................................................. 316
8.22.5.1.1.2 Embedments ........................................................ 316
8.22.5.1.1.3 Weight-to-perimeter ratio ......................................... 317
8.22.5.1.1.2 Gypsum wallboard protection ....................................... 317
8.22.5.1.1.2.1 Attachment ........................................................ 317
8.22.5.1.1.2.2 Gypsum wallboard equivalent to concrete ........................................... 317
8.22.5.1.1.3 Sprayed fire-resistant materials ........................................ 317
8.22.5.1.1.3.1 Material-dependent constants ....................................... 317
8.22.5.1.1.3.2 Identification ...................................................... 317
8.22.5.1.1.4 Concrete-protected columns ........................................ 317
8.22.5.1.1.4.1 Reentrant space filled .......................................... 318
8.22.5.1.1.4.2 Concrete properties unknown ....................................... 318
8.22.5.1.1.4.3 Minimum concrete cover ........................................ 318
8.22.5.1.1.4.4 Minimum precast concrete cover .................................... 318
8.22.5.1.1.4.5 Masonry protection ............................................... 318
8.22.5.1.1.4.6 Equivalent concrete masonry thickness ........................................ 318
8.22.5.2 Structural steel beams and girders ...................................... 319
8.22.5.2.1 Determination of fire resistance ...................................... 319
8.22.5.2.1.1 Weight-to-heated perimeter ......................................... 319
8.22.5.2.1.2 Beam and girder substitutions ....................................... 319
8.22.5.2.2 Sprayed fire-resistant materials ...................................... 319
8.22.5.2.2.1 Minimum thickness ................................................ 319
8.22.5.2.3 Structural steel trusses ................................................ 319
8.22.6 Wood assemblies ............................................................. 320
8.22.6.1 General ................................................................. 320

xxviii
8.22.6.1.1 Maximum fire-resistance rating ................................................................. 320
8.22.6.1.2 Dissimilar membranes .............................................................................. 320
8.22.6.2 Walls, floors and roofs ................................................................................. 320
8.22.6.2.1 Fire-resistance rating of wood frame assemblies ...................................... 322
8.22.6.2.2 Time assigned to membranes ................................................................. 322
8.22.6.2.3 Exterior walls ............................................................................................ 322
8.22.6.2.4 Floors and roofs ....................................................................................... 322
8.22.6.2.5 Additional protection ................................................................................ 322
8.22.6.2.6 Fastening .................................................................................................... 322
PART 9: INTERIOR FINISHES ......................................................................................... 323
9.1 SCOPE .................................................................................................................... 323
9.1.1 Scope .................................................................................................................. 323
9.2 GENERAL ............................................................................................................. 323
9.2.1 Interior wall and ceiling finish ......................................................................... 323
9.2.2 Interior floor finish ............................................................................................ 323
9.2.3 Decorative materials and trim ........................................................................... 323
9.2.4 Applicability ...................................................................................................... 323
9.2.5 Application ......................................................................................................... 323
9.2.6 Windows ........................................................................................................... 323
9.2.7 Foam plastics ..................................................................................................... 323
9.3 WALL AND CEILING FINISHES ......................................................................... 323
9.3.1 General ............................................................................................................. 323
9.3.1.1 Interior wall and ceiling finish materials tested in accordance with international best practice (e.g. ASTM E84) .......................................................................................... 323
9.3.1.1.1 Acceptance criteria for testing wall and ceiling finish materials .................. 323
9.3.1.2 Interior wall and ceiling finish materials tested in accordance with ASTM E84 .......................................................... 324
9.3.1.3 Interior wall and ceiling finish materials with different requirements .......... 324
9.3.2 Thickness exemption ......................................................................................... 324
9.3.3 Heavy timber exemption ................................................................................... 324
9.3.4 Foam plastics ..................................................................................................... 324
9.3.5 Textile wall coverings ....................................................................................... 324
9.3.5.1 Room corner test for textile wall coverings and expanded vinyl wall coverings .................................................. 324
9.3.5.1.1 Acceptance criteria for NFPA 265 ............................................................... 324
9.3.5.2 Acceptance criteria for textile and expanded vinyl wall or ceiling coverings .... 324
9.3.6 Textile ceiling coverings .................................................................................... 325
9.3.7 Expanded vinyl wall coverings ........................................................................... 325
9.3.8 Expanded vinyl ceiling coverings ..................................................................... 325
9.3.9 High-density polyethylene (HDPE) and polypropylene (PP) ......................... 325
9.3.10 Site-fabricated stretch systems ....................................................................... 325
9.3.11 Laminated products factory produced with a wood substrate ....................... 325
9.3.12 Facings or wood veneers intended to be applied on site over a wood substrate ........................................................................................................................... 325
9.3.13 Interior finish requirements based on occupancy ........................................... 325
9.3.14 Stability ............................................................................................................ 326
9.3.15 Application of interior finish materials to fire-resistance-rated or noncombustible .......................................................... 326
9.3.15.1 Direct attachment and furred construction .................................................. 327
9.3.15.1.1 Furred construction .................................................................................. 327
9.3.15.2 Set-out construction ...................................................................................... 327
9.3.15.2.1 Hangers and assembly members .............................................................. 327
9.3.15.3 Heavy timber construction ........................................................................... 327
9.3.15.4 Materials .................................................................................................... 327
9.4 INTERIOR FLOOR FINISH ....................................................................................... 328
9.4.1 General ............................................................................................................. 328
9.4.2 Classification ...................................................................................................... 328
9.4.3 Testing and identification .................................................................................. 328
9.4.4 Interior floor finish requirements ..................................................................... 328
9.4.4.1 Test requirement ............................................................................................ 328
9.4.4.2 Minimum critical radiant flux ....................................................................... 328
9.5 COMBUSTIBLE MATERIALS IN TYPES I CONSTRUCTION ................................... 328
9.5.1 Application ........................................................................................................ 328
9.5.1.1 Subfloor construction ..................................................................................... 328
9.5.1.2 Wood finish flooring ..................................................................................... 329
9.5.1.3 Insulating boards ........................................................................................................ 329
9.6 DECORATIVE MATERIALS AND TRIM ........................................................................... 329
9.6.1 General ........................................................................................................................... 329
9.6.2 Combustible decorative materials .................................................................................. 329
9.6.3 Occupancy-based requirements ..................................................................................... 329
9.6.4 Acceptance criteria and reports ...................................................................................... 330
9.6.5 Foam plastic ................................................................................................................... 330
9.6.6 Pyroxylin plastic ............................................................................................................ 330
9.6.7 Interior trim .................................................................................................................... 330
9.6.8 Interior floor-wall base .................................................................................................... 330
7 INSULATION ......................................................................................................................... 330
9.7 Insulation ........................................................................................................................... 330
9.8 ACOUSTICAL CEILING SYSTEMS ................................................................................... 330
9.8.1 Acoustical ceiling systems ............................................................................................ 330
9.8.1.1 Materials and installation ......................................................................................... 330
9.8.1.1.1 Suspended acoustical ceilings .............................................................................. 330
9.8.1.1.2 Fire-resistance-rated construction ...................................................................... 330
9.10 INTERIOR WALL AND CEILING FINISHES ................................................................. 330
9.10 General ........................................................................................................................... 330
9.10.2 Waterproof wall finish ................................................................................................... 330
9.10.2.1 Waterproofing of interior finishes ........................................................................... 331
9.10.2.2 Waterproof finish .................................................................................................... 331
9.10.3 Wall tile ....................................................................................................................... 331
9.10.3.1 Wall tile base and adhesive .................................................................................... 331
9.10.3.2 Mortar for ceramic tile ........................................................................................... 331
9.10.3.3 Adhesive for ceramic tile ....................................................................................... 331
9.11 FLOORING ......................................................................................................................... 331
9.11.1 General ......................................................................................................................... 331
9.11.1.1 Finished flooring shall be provided in all residential occupancies .......................... 331
9.11.1.2 Finished flooring materials .................................................................................... 331
9.11.1.3 Wood sleeper ........................................................................................................... 331
9.11.2 Wood strip flooring ...................................................................................................... 331
9.11.2.1 Dimensions ............................................................................................................ 331
9.11.2.2 Underlay ................................................................................................................ 331
9.11.2.3 Laying of wood strip flooring ............................................................................... 331
9.11.3 Parquet flooring .......................................................................................................... 332
PART 10: FIRE PROTECTION AND LIFE SAFETY SYSTEMS ................................................ 333
10.1 GENERAL .......................................................................................................................... 333
10.1.1 Scope ............................................................................................................................ 333
10.1.2 Fire protection systems ................................................................................................. 333
10.1.3 Modifications ............................................................................................................... 333
10.1.4 Threads ....................................................................................................................... 333
10.1.5 Acceptance tests ........................................................................................................ 333
10.1.6 Supervisory service ..................................................................................................... 333
10.1.6.1 Automatic sprinkler systems .................................................................................. 333
10.1.6.2 Integrated testing .................................................................................................... 333
10.1.6.2.1 High-rise buildings ............................................................................................ 333
10.1.6.2.2 Smoke control systems ...................................................................................... 334
10.1.6.3 Fire alarm systems .................................................................................................. 334
10.1.6.4 Group H ................................................................................................................... 334
10.1.7 Fire areas ...................................................................................................................... 334
10.2 FIRE PUMP AND RISER ROOM SIZE ........................................................................ 334
10.2.1 Pump and riser room size ............................................................................................ 334
10.2.1.1 Access .................................................................................................................... 334
10.2.1.2 Marking on access doors ....................................................................................... 334
10.2.1.3 Environment ......................................................................................................... 334
10.2.1.4 Lighting ................................................................................................................. 335
10.3 AUTOMATIC SPRINKLER SYSTEMS ............................................................................. 335
10.3.1 General ....................................................................................................................... 335
10.3.1.1 Alternative protection ............................................................................................ 335
10.3.2 Where required ........................................................................................................... 335

xxx
10.3.2.1 Group A ................................................................. 335
10.3.2.1.1 Group A-1 ....................................................... 335
10.3.2.1.2 Group A-2 ....................................................... 335
10.3.2.1.3 Group A-3 ....................................................... 335
10.3.2.1.4 Group A-4 ....................................................... 336
10.3.2.1.5 Group A-5 ....................................................... 336
10.3.2.1.5.1 Spaces under grandstands or bleachers ........... 336
10.3.2.1.6 Assembly occupancies on roofs ................. 336
10.3.2.1.7 Multiple fire areas............................... 336
10.2.2 Ambulatory care facilities ............................................. 336
10.3.2.3 Group E .......................................................... 337
10.3.2.4 Group F-1 ......................................................... 337
10.3.2.4.1 Woodworking operations ..................................... 337
10.3.2.5 Group H .................................................. 337
10.3.2.5.1 General .................................................. 337
10.3.2.5.2 Group H-5 occupancies .................................. 337
10.3.2.5.3 Pyroxylon plastics ........................................... 337
10.3.2.6 Group I .................................................. 337
10.3.2.7 Group M .................................................. 338
10.3.2.7.1 High-piled storage ......................................... 338
10.3.2.8 Group R .................................................. 338
10.3.2.8.1 Group R-3 .................................................. 338
10.3.2.8.2 Group R-4, Condition 1 .................................. 338
10.3.2.8.3 Group R-4, Condition 2 .................................. 338
10.3.2.8.4 Care facilities ............................................... 338
10.3.2.9 Group S-1 .................................................. 338
10.3.2.9.1 Repair garages .............................................. 339
10.3.2.9.2 Bulk storage of tires ......................................... 339
10.3.2.10 Group S-2 enclosed parking garages ........................................... 339
10.3.2.10.1 Commercial parking garages ................................ 339
10.3.2.11 Specific building areas and hazards ......................... 339
10.3.2.11.1 Stories without openings ................................ 339
10.3.2.11.1.1 Opening dimensions and access ....................... 340
10.3.2.11.1.2 Openings on one side only ............................. 340
10.3.2.11.1.3 Basements ............................................. 340
10.3.2.11.1.2 Rubbish and linen chutes ............................... 340
10.3.2.11.1.3 Buildings 55 feet or more in height .................. 340
10.3.2.11.1.4 Ducts conveying hazardous exhausts .................. 340
10.3.2.11.1.5 Commercial cooking operations ....................... 340
10.3.2.11.1.6 Other required suppression systems ................. 340
10.3.2.11.1.7 During construction .................................... 341
10.3.3 Installation requirements .............................................. 341
10.3.3.1 Standards .................................................. 341
10.3.3.1.1 NFPA 13 sprinkler systems .................................. 341
10.3.3.1.1.1 Exempt locations ....................................... 341
10.3.3.1.1.2 Bathrooms ............................................. 341
10.3.3.1.2 NFPA 13R sprinkler systems ................................ 341
10.3.3.1.2.1 Balconies and decks ................................... 341
10.3.3.1.2.2 Open-ended corridors .................................. 342
10.3.3.1.2.3 Attics .................................................. 342
10.3.3.1.3 NFPA 13D sprinkler systems .............................. 342
10.3.3.2 Quick-response and residential sprinklers ..................... 342
10.3.3.3 Obstructed locations ............................................. 343
10.3.3.4 Actuation .................................................. 343
10.3.3.5 Water supplies ................................................ 343
10.3.3.5.1 Domestic services ........................................ 343
10.3.3.5.2 Residential combination services ......................... 343
10.3.3.6 Hose threads .................................................. 343
10.3.3.7 Fire department connections .................................. 343
10.3.3.8 Limited area sprinkler systems ................................ 343
10.3.3.8.1 Number of sprinklers ..................................... 343

xxxi
10.3.3.8.2 Occupancy hazard classification ........................................................... 343
10.3.3.8.3 Piping arrangement .............................................................................. 343
10.3.3.8.4 Supervision .......................................................................................... 343
10.3.3.8.5 Calculations ......................................................................................... 344
10.3.4 Sprinkler system supervision and alarms ...................................................... 344
10.3.4.1 Monitoring ............................................................................................... 344
10.3.4.2 Alarms ...................................................................................................... 344
10.3.4.3 Floor control valves ............................................................................... 344
10.3.5 Testing and maintenance ........................................................................... 344
10.4 ALTERNATIVE AUTOMATIC FIRE-EXTINGUISHING SYSTEMS ............... 344
10.4.1 General ........................................................................................................ 344
10.4.2 Where permitted .......................................................................................... 345
10.4.2.1 Restriction on using automatic sprinkler system exceptions or reductions. 345
10.4.2.2 Commercial hood and duct systems ...................................................... 345
10.4.3 Installation .................................................................................................... 345
10.4.3.1 Electrical wiring ..................................................................................... 345
10.4.3.2 Actuation ................................................................................................. 345
10.4.3.3 System interlocking ............................................................................... 345
10.4.3.4 Alarms and warning signs .................................................................... 345
10.4.3.5 Monitoring .............................................................................................. 345
10.4.3.6 Inspection and testing ............................................................................ 345
10.4.4.1 Inspection ............................................................................................... 345
10.4.4.2 Alarm testing ........................................................................................... 346
10.4.4.2.1 Audible and visible signals ................................................................ 346
10.4.4.3 Monitor testing ....................................................................................... 346
10.4.5 Wet-chemical systems ............................................................................... 346
10.4.6 Dry-chemical systems .............................................................................. 346
10.4.7 Foam systems ............................................................................................. 346
10.4.8 Carbon dioxide systems ............................................................................ 346
10.4.9 Halon systems ............................................................................................. 346
10.4.10 Clean-agent systems ................................................................................ 346
10.4.11 Automatic water mist systems ................................................................. 346
10.4.11.1 Design and installation requirements ..................................................... 346
10.4.11.1.1 General .............................................................................................. 346
10.4.11.1.2 Actuation .......................................................................................... 346
10.4.11.1.3 Water supply protection ................................................................... 346
10.4.11.1.4 Secondary water supply .................................................................. 346
10.4.11.2 Water mist system supervision and alarms .......................................... 347
10.4.11.2.1 Monitoring ....................................................................................... 347
10.4.11.2.2 Alarms .............................................................................................. 347
10.4.11.2.3 Floor control valves ........................................................................ 347
10.4.11.3 Testing and maintenance ..................................................................... 347
10.4.12 Commercial cooking systems .................................................................. 347
10.4.12.1 Manual system operation ..................................................................... 347
10.4.12.2 System interconnection ........................................................................ 347
10.4.12.3 Carbon dioxide systems ....................................................................... 347
10.4.12.3.1 Ventilation system .......................................................................... 347
10.4.12.4 Special provisions for automatic sprinkler systems ............................. 348
10.4.12.4.1 Listed sprinklers .............................................................................. 348
10.4.13 Domestic cooking systems ...................................................................... 348
10.4.13.1 Protection from fire ............................................................................... 348
10.4.13.1.1 Automatic fire-extinguishing system ............................................... 348
10.4.13.1.2 Ignition prevention .......................................................................... 348
10.4.14 Aerosol fire-extinguishing systems ......................................................... 348
10.5 FIRE HYDRANTSYSTEMS ............................................................................. 348
10.5.1 General ....................................................................................................... 348
10.5.2 Installation standard ................................................................................... 348
10.5.3 Required installations ................................................................................ 349
10.5.3.1 Height .................................................................................................... 349
10.5.3.2 Group A ................................................................................................ 349
10.5.3.3 Covered and open mall buildings .......................................................... 349
10.6.5 Conspicuous location.
10.6.6 Locking Fire hydrant outlet caps.
10.6.4 Cooking equipment fires.
10.6.5 Conspicuous location.
10.6.6 Unobstructed and unobscured.
10.6.7 Hangers and brackets.
10.6.8 Cabinets.
10.6.9 Extinguisher installation.
10.6.9.1 Extinguishers weighing 40 pounds or less.
10.6.9.2 Extinguishers weighing more than 40 pounds.
10.6.9.3 Floor clearance.
10.6.10 Wheeled units.
10.7 FIRE ALARM AND DETECTION SYSTEMS
10.7.1 General.
10.7.1.1 Construction documents.
10.7.1.2 Fire alarm shop drawings.
10.7.1.3 Equipment.
10.7.2 Where required—new buildings and structures.
10.7.2.1 Group A.
10.7.2.1.1 System initiation in Group A occupancies with an occupant load of 1,000 or more.
10.7.2.1.2 Emergency voice/alarm communication captions.
10.7.2.2 Group B.
10.7.2.2.1 Ambulatory care facilities.
10.7.2.3 Group E.
10.7.2.4 Group F.
10.7.2.5 Group H.
10.7.2.6 Group I.
10.7.2.6.1 Group I-1.
10.7.2.6.1.1 Smoke alarms.
10.7.2.6.2 Group I-2.
10.7.2.6.3 Group I-3 occupancies.
10.7.2.6.3.1 System initiation.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.7.2.6.3.2</td>
<td>Manual fire alarm boxes</td>
</tr>
<tr>
<td>10.7.2.6.3.2.1</td>
<td>Manual fire alarm boxes in detainee areas</td>
</tr>
<tr>
<td>10.7.2.6.3.3</td>
<td>Automatic smoke detection system</td>
</tr>
<tr>
<td>10.7.2.7</td>
<td>Group M.</td>
</tr>
<tr>
<td>10.7.2.7.1</td>
<td>Occupant notification</td>
</tr>
<tr>
<td>10.7.2.8</td>
<td>Group R-1</td>
</tr>
<tr>
<td>10.7.2.8.1</td>
<td>Manual fire alarm system</td>
</tr>
<tr>
<td>10.7.2.8.2</td>
<td>Automatic smoke detection system</td>
</tr>
<tr>
<td>10.7.2.8.3</td>
<td>Smoke alarms</td>
</tr>
<tr>
<td>10.7.2.9</td>
<td>Group R-2</td>
</tr>
<tr>
<td>10.7.2.9.1</td>
<td>Manual fire alarm system</td>
</tr>
<tr>
<td>10.7.2.9.2</td>
<td>Smoke alarms</td>
</tr>
<tr>
<td>10.7.2.9.3</td>
<td>Group R-2 college and university buildings</td>
</tr>
<tr>
<td>10.7.2.10</td>
<td>Single- and multiple-station smoke alarms</td>
</tr>
<tr>
<td>10.7.2.10.1</td>
<td>Group R-1</td>
</tr>
<tr>
<td>10.7.2.10.2</td>
<td>Groups R-2, R-3, R-4 and I-1</td>
</tr>
<tr>
<td>10.7.2.10.4</td>
<td>Installation near bathrooms</td>
</tr>
<tr>
<td>10.7.2.10.5</td>
<td>Interconnection</td>
</tr>
<tr>
<td>10.7.2.10.6</td>
<td>Power source</td>
</tr>
<tr>
<td>10.7.2.10.7</td>
<td>Smoke detection system</td>
</tr>
<tr>
<td>10.7.2.11</td>
<td>Special amusement buildings</td>
</tr>
<tr>
<td>10.7.2.11.1</td>
<td>Alarm</td>
</tr>
<tr>
<td>10.7.2.11.2</td>
<td>System response</td>
</tr>
<tr>
<td>10.7.2.11.3</td>
<td>Emergency voice/alarm communication system</td>
</tr>
<tr>
<td>10.7.2.12</td>
<td>High-rise buildings</td>
</tr>
<tr>
<td>10.7.2.12.1</td>
<td>Automatic smoke detection</td>
</tr>
<tr>
<td>10.7.2.12.1.1</td>
<td>Area smoke detection</td>
</tr>
<tr>
<td>10.7.2.12.1.2</td>
<td>Duct smoke detection</td>
</tr>
<tr>
<td>10.7.2.12.2</td>
<td>Fire department communication system</td>
</tr>
<tr>
<td>10.7.2.13</td>
<td>Atriums connecting more than two stories</td>
</tr>
<tr>
<td>10.7.2.14</td>
<td>High-piled combustible storage areas</td>
</tr>
<tr>
<td>10.7.2.15</td>
<td>Aerosol storage uses</td>
</tr>
<tr>
<td>10.7.2.16</td>
<td>Timber, wood structural panel and veneer mills</td>
</tr>
<tr>
<td>10.7.2.17</td>
<td>Underground buildings with smoke control systems</td>
</tr>
<tr>
<td>10.7.2.17.1</td>
<td>Smoke detectors</td>
</tr>
<tr>
<td>10.7.2.17.2</td>
<td>Alarm required</td>
</tr>
<tr>
<td>10.7.2.18</td>
<td>Deep underground buildings</td>
</tr>
<tr>
<td>10.7.2.19</td>
<td>Covered and open mall buildings</td>
</tr>
<tr>
<td>10.7.2.20</td>
<td>Residential aircraft hangars</td>
</tr>
<tr>
<td>10.7.2.21</td>
<td>Airport traffic control towers</td>
</tr>
<tr>
<td>10.7.2.21.1</td>
<td>Airport traffic control towers with multiple exits and automatic sprinklers</td>
</tr>
<tr>
<td>10.7.2.21.2</td>
<td>Other airport traffic control towers</td>
</tr>
<tr>
<td>10.7.2.22</td>
<td>Battery rooms</td>
</tr>
<tr>
<td>10.7.2.23</td>
<td>Capacitor energy storage systems</td>
</tr>
<tr>
<td>10.7.3</td>
<td>Fire safety functions</td>
</tr>
<tr>
<td>10.7.3.1</td>
<td>Duct smoke detectors</td>
</tr>
<tr>
<td>10.7.3.2</td>
<td>Special locking systems</td>
</tr>
<tr>
<td>10.7.3.3</td>
<td>Elevator emergency operation</td>
</tr>
<tr>
<td>10.7.3.4</td>
<td>Wiring</td>
</tr>
<tr>
<td>10.7.4</td>
<td>Initiating devices</td>
</tr>
<tr>
<td>10.7.4.1</td>
<td>Protection of fire alarm control unit</td>
</tr>
<tr>
<td>10.7.4.2</td>
<td>Manual fire alarm boxes</td>
</tr>
<tr>
<td>10.7.4.2.1</td>
<td>Location</td>
</tr>
<tr>
<td>10.7.4.2.2</td>
<td>Height</td>
</tr>
<tr>
<td>10.7.4.2.3</td>
<td>Color</td>
</tr>
<tr>
<td>10.7.4.2.4</td>
<td>Signs</td>
</tr>
<tr>
<td>10.7.4.2.5</td>
<td>Protective covers</td>
</tr>
<tr>
<td>10.7.4.2.6</td>
<td>Unobstructed and unobscured</td>
</tr>
<tr>
<td>10.7.4.3</td>
<td>Automatic smoke detection</td>
</tr>
<tr>
<td>10.7.4.3.1</td>
<td>Automatic sprinkler system</td>
</tr>
<tr>
<td>10.7.5</td>
<td>Occupant notification systems</td>
</tr>
</tbody>
</table>

xxxiv
10.7.5.1 Presignal feature........................................................................................................367
10.7.5.2 Alarm notification appliances....................................................................................367
10.7.5.2.1 Audible alarms........................................................................................................367
10.7.5.2.1.1 Average sound pressure......................................................................................367
10.7.5.2.1.2 Maximum sound pressure....................................................................................367
10.7.5.2.2 Emergency voice/alarm communication systems..................................................367
10.7.5.2.2.1 Manual override....................................................................................................368
10.7.5.2.2.2 Live voice messages..............................................................................................368
10.7.5.2.2.3 Alternative uses.....................................................................................................368
10.7.5.2.2.4 Emergency voice/alarm communication captions............................................368
10.7.5.2.2.5 Emergency power..................................................................................................368
10.7.5.2.3 Visible alarms..........................................................................................................368
10.7.5.2.3.1 Public use areas and common use areas..............................................................368
10.7.5.2.3.3 Group R-2 ...........................................................................................................369
10.7.6 Installation and monitoring.............................................................................................369
10.7.6.2 Power supply..............................................................................................................369
10.7.6.2.3 Initiating device identification..................................................................................369
10.7.6.3.1 Annunciation............................................................................................................369
10.7.6.4 Zones........................................................................................................................369
10.7.6.4.1 Zoning indicator panel............................................................................................369
10.7.6.4.2 High-rise buildings..................................................................................................369
10.7.6.5 Access.......................................................................................................................370
10.7.6.6 Monitoring................................................................................................................370
10.7.6.6.1 Automatic telephone-dialing devices..............................................................370
10.7.6.6.2 Termination of monitoring service..........................................................................370
10.7.7 Acceptance tests and completion....................................................................................370
10.7.7.1 Single- and multiple-station alarm devices...............................................................370
10.7.7.2 Record of completion..................................................................................................370
10.7.7.3 Instructions................................................................................................................370
10.7.8 Inspection, testing and maintenance.............................................................................370
10.8 EMERGENCY ALARM SYSTEMS.............................................................................370
10.8.1 Group H occupancies....................................................................................................370
10.9 SMOKE CONTROL SYSTEMS......................................................................................370
10.9.1 Scope and purpose........................................................................................................370
10.9.2 General design requirements.......................................................................................370
10.9.3 Special inspection and test requirements.......................................................................371
10.9.4 Analysis........................................................................................................................371
10.9.4.1 Stack effect................................................................................................................371
10.9.4.2 Temperature effect of fire..........................................................................................371
10.9.4.3 Wind effect................................................................................................................371
10.9.4.4 HVAC systems.........................................................................................................371
10.9.4.5 Climate......................................................................................................................371
10.9.4.6 Duration of operation................................................................................................371
10.9.4.7 Smoke control system interaction............................................................................371
10.9.5 Smoke barrier construction..........................................................................................371
10.9.5.1 Total leakage area.....................................................................................................372
10.9.5.2 Testing of leakage area..............................................................................................372
10.9.5.3 Opening protection.....................................................................................................372
10.9.5.3.1 Group I-1, Condition 2; Group I-2; and ambulatory care facilities.......................372
10.9.5.3.2 Ducts and air transfer openings..........................................................................372
10.9.6 Pressurization method..................................................................................................372
10.9.6.1 Minimum pressure difference..................................................................................372
10.9.6.2 Maximum pressure difference................................................................................373
10.9.6.3 Pressurized stairways and elevator hoistways.........................................................373
10.9.7 Airflow design method..................................................................................................373
10.9.7.1 Prohibited conditions...............................................................................................373
10.9.8 Exhaust method..........................................................................................................373
10.9.8.1 Smoke layer..............................................................................................................373
10.9.9 Design fire....................................................................................................................373
10.9.9.1 Factors considered....................................................................................................373
10.9.9.2 Design fire fuel.........................................................................................................373
10.9.9.3 Heat-release assumptions ................................................................. 373
10.9.9.4 Sprinkler effectiveness assumptions .................................................. 373
10.9.10 Equipment ......................................................................................... 374
10.9.10.2 Ducts ........................................................................................... 374
10.9.10.3 Equipment, inlets and outlets .......................................................... 374
10.9.10.4 Automatic dampers ...................................................................... 374
10.9.10.5 Fans .............................................................................................. 374
10.9.11 Standby power .................................................................................. 374
10.9.11.1 Equipment room ........................................................................... 374
10.9.11.2 Power sources and power surges ..................................................... 374
10.9.12 Detection and control systems ............................................................. 375
10.9.12.1 Verification ................................................................................... 375
10.9.12.2 Wiring .......................................................................................... 375
10.9.12.3 Activation ..................................................................................... 375
10.9.12.3.1 Pressurization, airflow or exhaust method .................................. 375
10.9.12.3.2 Passive method ....................................................................... 375
10.9.12.4 Automatic control ....................................................................... 375
10.9.13 Control air tubing ............................................................................ 375
10.9.13.1 Materials ...................................................................................... 375
10.9.13.2 Isolation from other functions ....................................................... 376
10.9.13.3 Testing .......................................................................................... 376
10.9.14 Marking and identification ................................................................. 376
10.9.15 Control diagrams ............................................................................. 376
10.9.16 Fire fighter’s smoke control panel ....................................................... 376
10.9.16.1 Smoke control systems ................................................................ 376
10.9.16.2 Smoke control panel ................................................................... 376
10.9.16.3 Control action and priorities ......................................................... 377
10.9.17 System response time ..................................................................... 377
10.9.18 Acceptance testing ......................................................................... 377
10.9.18.1 Detection devices ........................................................................ 378
10.9.18.2 Ducts .......................................................................................... 378
10.9.18.3 Dampers ...................................................................................... 378
10.9.18.4 Inlets and outlets ......................................................................... 378
10.9.18.5 Fans ............................................................................................ 378
10.9.18.6 Smoke barriers ............................................................................ 378
10.9.18.7 Controls ....................................................................................... 378
10.9.18.8 Testing for smoke control ............................................................. 378
10.9.18.8.1 Scope of testing ...................................................................... 378
10.9.18.8.2 Qualifications ......................................................................... 378
10.9.18.8.3 Reports .................................................................................. 378
10.9.18.8.3.1 Report filing ....................................................................... 378
10.9.18.9 Identification and documentation ................................................ 378
10.9.19 System acceptance ......................................................................... 378
10.9.20 Smoke proof enclosures ................................................................. 379
10.9.20.1 Access ......................................................................................... 379
10.9.20.2 Construction ................................................................................. 379
10.9.20.2.1 Door closers ........................................................................... 379
10.9.20.3 Natural ventilation alternative ....................................................... 379
10.9.20.3.1 Balcony doors ...................................................................... 379
10.9.20.3.2 Vestibule doors ...................................................................... 379
10.9.20.3.3 Vestibule ventilation ................................................................. 379
10.9.20.4 Mechanical ventilation alternative ................................................. 379
10.9.20.4.1 Vestibule doors ...................................................................... 379
10.9.20.4.2 Vestibule ventilation ................................................................. 380
10.9.20.4.2.1 Engineered ventilation system ............................................ 380
10.9.20.4.3 Smoke trap ............................................................................. 380
10.9.20.4.4 Stairway or ramp shaft air movement system ................................ 380
10.9.20.5 Stairway and ramp pressurization alternative .................................. 380
10.9.20.6 Ventilating equipment ................................................................... 380
10.9.20.6.1 Ventilation systems .................................................................. 380
10.9.20.6.2 Standby power ........................................................................ 381
10.20.6.3 Acceptance and testing ................................................................. 381
10.21 Elevator hoistway pressurization alternative ....................................... 381
10.21.1 Pressurization requirements ............................................................. 381
10.21.1.1 Use of ventilation systems ............................................................ 382
10.21.1.2 Rational analysis ............................................................................... 382
10.21.1.3 Ducts for system ............................................................................... 382
10.21.4.1 Fire resistance .................................................................................. 382
10.21.4.2 Smoke detection ............................................................................... 382
10.21.4.3 Separate systems .............................................................................. 382
10.21.4.4 Fan capacity .................................................................................... 382
10.21.5 Standby power .................................................................................... 382
10.21.6 Activation of pressurization system .................................................... 382
10.21.7 Testing ............................................................................................... 382
10.21.8 Marking and identification .................................................................. 382
10.21.9 Control diagrams .................................................................................. 382
10.21.10 Control panel .................................................................................... 382
10.21.11 System response time ....................................................................... 382
10.2 SMOKE AND HEAT REMOVAL .............................................................. 382
  10.1 General .............................................................................................. 382
  10.2 Where required ..................................................................................... 382
  10.2.1 Group F-1 or S-1 .............................................................................. 383
  10.2.2 High-piled combustible storage ......................................................... 383
  10.3 Smoke and heat vents .......................................................................... 383
  10.3.1 Listing and labeling ............................................................................. 383
  10.3.2 Smoke and heat vent locations .......................................................... 383
  10.3.3 Smoke and heat vents area ................................................................. 383
  10.4 Mechanical smoke removal systems ...................................................... 383
  10.4.1 Automatic sprinklers required ............................................................. 384
  10.4.2 Exhaust fan construction .................................................................... 384
  10.4.3 System design criteria ........................................................................ 384
  10.4.3.1 Makeup air ....................................................................................... 384
  10.4.4 Activation .......................................................................................... 384
  10.4.5 Manual control location ..................................................................... 384
  10.4.6 Control wiring .................................................................................... 384
  10.4.7 Controls ............................................................................................ 384
  10.5 Maintenance ........................................................................................ 384
  10.11 FIRE COMMAND CENTER ............................................................... 384
    10.11.1 General ......................................................................................... 384
    10.11.1.1 Location and access .................................................................... 384
    10.11.1.2 Separation .................................................................................... 384
    10.11.1.3 Size ............................................................................................. 384
    10.11.1.4 Layout approval .......................................................................... 384
    10.11.1.5 Storage ......................................................................................... 384
    10.11.1.6 Required features ....................................................................... 384
  10.12 FIRE DEPARTMENT CONNECTIONS .............................................. 386
    10.12.1 Installation ...................................................................................... 386
    10.12.2 Location ........................................................................................ 386
    10.12.2.1 Visible location ............................................................................. 386
    10.12.2.2 Existing buildings ........................................................................ 386
    10.12.3 Fire hose threads ............................................................................ 386
    10.12.4 Access ........................................................................................... 386
    10.12.4.1 Locking fire department connection caps ..................................... 386
    10.12.4.2 Clear space around connections .................................................. 386
    10.12.4.3 Physical protection ...................................................................... 387
    10.12.5 Signs ............................................................................................. 387
    10.12.6 Backflow protection ....................................................................... 387
    10.13 FIRE PUMPS ................................................................................... 387
    10.13.1 General ........................................................................................ 387
    10.13.2 Protection against interruption of service ........................................ 387
    10.13.2.1 Protection of fire pump rooms ..................................................... 387
    10.13.2.2 Circuits supplying fire pumps ...................................................... 387

xxxvii
10.13.3 Temperature of pump room .................................................................................................. 387
10.13.3.1 Engine manufacturer's recommendation ........................................................................ 387
10.13.4 Valve supervision .................................................................................................................. 387
10.13.4.1 Test outlet valve supervision .......................................................................................... 388
10.13.5 Acceptance test ..................................................................................................................... 388
10.14 EMERGENCY RESPONDER SAFETY FEATURES .......................................................... 388
10.14.1 Shaftway markings .............................................................................................................. 388
10.14.1.1 Exterior access to shaftways ......................................................................................... 388
10.14.1.2 Interior access to shaftways .......................................................................................... 388
10.14.2 Equipment room identification ........................................................................................... 388
10.15 CARBON MONOXIDE DETECTION .................................................................................. 388
10.15.1 General ............................................................................................................................... 388
10.15.1.1 Where required ............................................................................................................ 388
10.15.1.2 Fuel-burning appliances and fuel-burning fireplaces ...................................................... 388
10.15.1.3 Fuel burning, forced-air furnaces ................................................................................. 388
10.15.1.4 Fuel-burning appliances outside of dwelling units, sleeping units and .................... 388
10.15.1.5 Private garages ............................................................................................................. 389
10.15.1.6 Exempt garages ........................................................................................................... 389
10.15.2 Locations ............................................................................................................................. 389
10.15.2.1 Dwelling units .............................................................................................................. 389
10.15.2.2 Sleeping units .............................................................................................................. 389
10.15.2.3 Group E occupancies ................................................................................................... 389
10.15.3 Carbon monoxide detection .............................................................................................. 390
10.15.4 Carbon monoxide alarms .................................................................................................. 390
10.15.4.1 Power source .............................................................................................................. 390
10.15.4.2 Listings ......................................................................................................................... 390
10.15.4.3 Locations ...................................................................................................................... 390
10.15.4.4 Combination alarms ..................................................................................................... 390
10.15.5 Carbon monoxide detection systems ................................................................................. 390
10.15.5.1 General ....................................................................................................................... 390
10.15.5.2 Locations ...................................................................................................................... 390
10.15.5.3 Combination detectors ................................................................................................. 390
10.15.6 Maintenance ....................................................................................................................... 390
10.16 GAS DETECTION SYSTEMS ............................................................................................ 390
10.16.1 Gas detection systems ........................................................................................................ 390
10.16.2 Permits .................................................................................................................................. 390
10.16.2.1 Construction documents ............................................................................................. 390
10.16.3 Equipment .......................................................................................................................... 390
10.16.4 Power connections .............................................................................................................. 390
10.16.5 Emergency and standby power ........................................................................................ 390
10.16.6 Sensor locations ................................................................................................................ 390
10.16.7 Gas sampling ........................................................................................................................ 391
10.16.8 System activation ................................................................................................................. 391
10.16.9 Signage ................................................................................................................................ 391
10.16.10 Fire alarm system connections ....................................................................................... 391
10.16.11 Inspection, testing and sensor calibration ....................................................................... 391
10.17 MASS NOTIFICATION SYSTEMS ................................................................................. 391
10.17.1 College and university campuses ....................................................................................... 391
10.18 EMERGENCY RESPONDER RADIO COVERAGE ....................................................... 391
10.18.1 General .................................................................................................................................. 391
PART 11: MEANS OF ESCAPE ................................................................................................. 392
11.1 ADMINISTRATION .................................................................................................................. 392
11.1.1 General .................................................................................................................................. 392
11.1.2 Minimum requirements ...................................................................................................... 392
11.2 MAINTENANCE AND PLANS ............................................................................................. 392
11.2.1 Maintenance ......................................................................................................................... 392
11.2.2 Fire safety and evacuation plans ........................................................................................ 392
11.3 GENERAL MEANS OF ESCAPE ....................................................................................... 392
11.3.1 Applicability ....................................................................................................................... 392
11.3.2 Ceiling height ....................................................................................................................... 392
11.3.3 Protruding objects ............................................................................................................... 393
11.3.3.1 Headroom ................................................................. 393
11.3.3.2 Post-mounted objects .................................................. 393
11.3.3.4 Clear width ................................................................. 393
11.3.4 Slip-resistant surface ..................................................... 393
11.3.5 Elevation change ............................................................ 393
11.3.6 Means of Escape continuity ............................................. 394
11.3.7 Elevators, escalators and moving walks ................................. 394
11.4 OCCUPANT LOAD .............................................................. 394
11.4.1 Design occupant load ...................................................... 394
11.4.1.1 Methods of Measurement ............................................... 394
11.4.2 Cumulative occupant loads ............................................... 394
11.4.2.1 Intervening spaces or accessory areas ............................... 394
11.4.2.2 Adjacent levels for mezzanines ....................................... 394
11.4.2.3 Adjacent stories ............................................................ 395
11.4.3 Multiple function occupant load ......................................... 395
11.4.4 Multiple occupancies ...................................................... 395
11.4.5 Areas without fixed seating .............................................. 395
11.4.5.1 Increased occupant load ............................................... 395
11.4.6 Fixed seating ................................................................. 396
11.4.7 Outdoor areas ............................................................... 396
11.4.8 Concentrated business use areas ....................................... 396
11.4.9 Posting of occupant load ................................................ 396
11.5 MEANS OF ESCAPE SIZING ................................................ 396
11.5.1 General ................................................................. 396
11.5.2 Minimum width based on component .................................. 396
11.5.3 Required capacity based on occupant load ............................ 397
11.5.3.1 Stairways ................................................................. 397
11.5.3.2 Other Escape components ............................................. 397
11.5.4 Continuity ................................................................. 397
11.5.5 Distribution of minimum width and required capacity ............... 398
11.5.6 Escape convergence ....................................................... 398
11.5.7 Encroachment ............................................................... 398
11.5.7.1 Doors ................................................................. 398
11.5.7.2 Other projections ........................................................ 398
11.5.7.3 Protruding objects ...................................................... 398
11.6 NUMBER OF EXITS AND EXIT ACCESS DOORWAYS .................. 398
11.6.1 General ................................................................. 398
11.6.2 Escape from spaces ...................................................... 398
11.6.2.1 Escape based on occupant load and common path of Escape travel distance ............................... 398
11.6.2.1.1 Three or more exits or exit access doorways ....................... 399
11.6.2.2 Escape based on use .................................................. 399
11.6.2.2.1 Boiler, incinerator and furnace rooms ............................ 399
11.6.2.2.2 Refrigeration machinery rooms .................................... 400
11.6.2.2.3 Refrigerated rooms or spaces ...................................... 400
11.6.2.2.4 Group I-4 means of Escape ....................................... 400
11.6.2.2.5 Vehicular ramps .................................................. 400
11.6.2.2.6 Groups R-3 and R-4 .............................................. 400
11.6.3 Escape from stories or occupied roofs ................................ 400
11.6.3.1 Adjacent storey ...................................................... 400
11.6.3.2 Escape based on occupant load ...................................... 401
11.6.3.3 Single exits ............................................................. 401
11.6.3.4 Mixed occupancies .................................................... 402
11.7 EXIT AND EXIT ACCESS DOORWAY CONFIGURATION ............... 402
11.7.1 General ................................................................. 402
11.7.1.1.1 Measurement point .................................................. 403
11.7.1.2 Three or more exits or exit access doorways ....................... 403
11.7.1.3 Remoteness of exit access stairways or ramps ....................... 403
11.7.1.3.1 Three or more exit access stairways or ramps ....................... 403
11.8 MEANS OF ESCAPE ILLUMINATION ......................................... 403
11.8.1 Means of Escape illumination ............................................ 403
11.8.2 Illumination required .................................................... 403
11.10.1.9.2 Hardware height.
11.10.1.9.1 Hardware.
11.10.1.8 Door arrangement.
11.10.1.7 Door operatio
11.10.1.6.4.1 Remote operation of locks.
11.10.1.4.3 Special purpose horizontal sliding, accordion or folding doors.
11.10.1.4.3 Stairway width.
11.10.1.4.2 Area of refuge.
11.10.1.4.1.1 Escape component.
11.10.1.4.1.1 Projections into clear width.
11.10.1.1 Size of doors.
11.10.1.1 Accessible means of Escape required.
11.10.1.1 Areas of refuge.
11.10.1.1 Travel distance.
11.10.1.1 Stairway or elevator access.
11.10.1.1 Size.
11.10.1.1 Separation.
11.10.1.1 Two-way communication.
11.10.1.1 Exterior areas for assisted rescue.
11.10.1.1 Size.
11.10.1.1 Separation.
11.10.1.1 Openness.
11.10.1.1 Stairways.
11.10.1.1 Two-way communication.
11.10.1.1 System requirements.
11.10.1.1 Directions.
11.10.1.1 Signage.
11.9.11 Instructions.
11.10.1.10 DOORS, GATES AND TURNSTILES.
11.10.1.10.1 Doors.
11.10.1.10.1.1 Size of doors.
11.10.1.10.1.1 Projections into clear width.
11.10.1.10.1.2 Door swing.
11.10.1.10.1.2 Direction of swing.
11.10.1.10.1.3 Door opening force.
11.10.1.10.1.3 Location of applied forces.
11.10.1.10.1.4 Special doors.
11.10.1.10.1.4.1 Revolving doors.
11.10.1.10.1.4.1.1 Escape component.
11.10.1.10.1.4.1.2 Other than Escape component.
11.10.1.10.1.4.2 Power-operated doors.
11.10.1.10.1.4.3 Special purpose horizontal sliding, accordion or folding doors.
11.10.1.10.1.4.4 Locking arrangements in educational occupancies.
11.10.1.10.1.4.4.1 Remote operation of locks.
11.10.1.10.1.4.5 Security grilles.
11.10.1.10.1.5 Floor elevation.
11.10.1.10.1.6 Landings at doors.
11.10.1.10.1.7 Thresholds.
11.10.1.10.1.8 Door arrangement.
11.10.1.10.1.9 Door operations.
11.10.1.10.1.9.1 Hardware.
11.10.1.10.1.9.2 Hardware height.
11.10.1.9.3 Monitored or recorded Escape ............................................................... 415
11.10.1.9.4 Locks and latches .................................................................................. 415
11.10.1.9.6 Unlatching ............................................................................................. 416
11.10.1.9.6.1 Closet doors ....................................................................................... 416
11.10.1.9.7 Controlled Escape doors in Groups I-1 and I-2. ........................................... 416
11.10.1.9.8 Delayed Escape ..................................................................................... 417
11.10.1.9.9 Sensor release of electrically locked Escape doors ............................... 418
11.10.1.9.10 Door hardware release of electrically locked escape doors ............... 418
11.10.1.9.11 Locking arrangements in buildings within correctional facilities. .......... 418
11.10.1.9.12 Stairway doors ...................................................................................... 419
11.10.1.10 Panic and fire exit hardware ..................................................................... 419
11.10.1.10.1 Installation ........................................................................................... 419
11.10.1.10.2 Balanced doors .................................................................................... 419
11.10.2 Gates ........................................................................................................ 420
11.10.2.1 Stadiums .................................................................................................. 420
11.10.3 Turnstiles and similar devices ..................................................................... 420
11.10.3.1 Capacity .................................................................................................. 420
11.10.3.1.1 Clear width ........................................................................................... 420
11.10.3.2 Security access turnstiles .......................................................................... 420
11.10.3.3 High turnstile .......................................................................................... 421
11.10.3.4 Additional door ......................................................................................... 421
11.11 STAIRWAYS ................................................................................................. 421
11.11.1 General ...................................................................................................... 421
11.11.2 Width and capacity ..................................................................................... 421
11.11.3 Headroom .................................................................................................. 421
11.11.4 Walkline ..................................................................................................... 422
11.11.5 Stair treads and risers ................................................................................. 422
11.11.5.1 Dimension reference surfaces ................................................................. 422
11.11.5.2 Riser height and tread depth ................................................................. 422
11.11.5.3 Winder treads ......................................................................................... 422
11.11.5.4 Dimensional uniformity ......................................................................... 422
11.11.5.4.1 Nonuniform height risers .................................................................. 423
11.11.5.5 Nosing and riser profile ........................................................................ 423
11.11.5.5.1 Nosing projection size ....................................................................... 423
11.11.5.5.2 Nosing projection uniformity ............................................................. 423
11.11.5.5.3 Solid risers .......................................................................................... 423
11.11.6 Stairway landings ....................................................................................... 423
11.11.7 Stairway construction ................................................................................. 424
11.11.7.1 Stairway walking surface ....................................................................... 424
11.11.7.2 Outdoor conditions ................................................................................ 424
11.11.7.3 Enclosures under interior stairways .......................................................... 424
11.11.7.4 Enclosures under exterior stairways ....................................................... 424
11.11.8 Vertical rise ............................................................................................... 424
11.11.9 Curved stairways ....................................................................................... 424
11.11.10 Spiral stairways ....................................................................................... 424
11.11.11 Handrails .................................................................................................. 425
11.11.12 Stairway to roof ....................................................................................... 425
11.11.12.1 Stairway to elevator equipment ............................................................. 425
11.11.12.2 Roof access .......................................................................................... 425
11.11.13 Guards ..................................................................................................... 425
11.11.14 Alternating tread devices ......................................................................... 425
11.11.14.1 Handrails of alternating tread devices ................................................... 425
11.11.14.2 Treads of alternating tread devices ....................................................... 425
11.11.15 Ships ladders ............................................................................................ 426
11.11.15.1 Handrails of ships ladders ................................................................. 426
11.11.15.2 Treads of ships ladders ................................................................. 426
11.11.16 Ladders .................................................................................................... 426
11.12 RAMPS ........................................................................................................ 426
11.12.1 Scope .......................................................................................................... 426
11.12.2 Slope .......................................................................................................... 426
11.12.3 Cross slope ................................................................................................. 426
11.12.4 Vertical rise ................................................................. 427
11.12.5 Minimum dimensions.................................................. 427
11.12.5.1 Width and capacity .................................................. 427
11.12.5.2 Headroom .............................................................. 427
11.12.5.3 Restrictions ............................................................ 427
11.12.6 Landings ................................................................. 427
11.12.6.1 Slope ................................................................. 427
11.12.6.2 Width ................................................................. 427
11.12.6.3 Length ................................................................. 427
11.12.6.4 Change in direction .................................................. 427
11.12.6.5 Doorways ............................................................. 427
11.12.7 Ramp construction ...................................................... 427
11.12.7.1 Ramp surface ........................................................ 428
11.12.7.2 Outdoor conditions .................................................. 428
11.12.8 Handrails ............................................................... 428
11.12.9 Guards ................................................................. 428
11.12.10 Edge protection ........................................................ 428
11.12.10.1 Curb, rail, wall or barrier ........................................ 428
11.12.10.2 Extended floor or ground surface ........................... 428
11.13 EXIT SIGNS ............................................................ 428
11.13.1 Where required .......................................................... 428
11.13.2 Low-level exit signs in Group R-1 ............................... 429
11.13.3 Illumination ............................................................. 429
11.13.4 Raised character and braille exit signs .......................... 429
11.13.5 Internally illuminated exit signs .................................. 429
11.13.6 Externally illuminated exit signs ................................ 429
11.13.6.1 Graphics ............................................................. 429
11.13.6.2 Exit sign illumination .............................................. 429
11.13.6.3 Power source ........................................................ 429
11.14 HANDRAILS .............................................................. 429
11.14.1 Where required ........................................................ 429
11.14.2 Height ................................................................. 430
11.14.3 Handrail graspability ............................................... 430
11.14.3.1 Type I ............................................................... 430
11.14.3.2 Type II .............................................................. 430
11.14.4 Continuity ............................................................. 430
11.14.5 Fittings ................................................................. 431
11.14.6 Handrail extensions .................................................. 431
11.14.7 Clearance ............................................................. 431
11.14.8 Projections ............................................................ 431
11.14.9 Intermediate handrails .............................................. 431
11.15 GUARDS ................................................................. 431
11.15.1 General ............................................................... 431
11.15.2 Where required ......................................................... 431
11.15.2.1 Glazing ............................................................... 431
11.15.3 Height ................................................................. 432
11.15.4 Opening limitations .................................................. 433
11.15.5 Screen porches ......................................................... 433
11.15.6 Mechanical equipment, systems and devices ............... 433
11.15.7 Roof access .......................................................... 433
11.15.8 Window openings .................................................... 433
11.15.8.1 Window opening control devices ............................ 434
11.16 EXIT ACCESS .......................................................... 434
11.16.1 General ............................................................... 434
11.16.2 Escape through intervening spaces ......................... 434
11.16.2.1 Multiple tenants .................................................. 435
11.17 EXIT ACCESS TRAVEL DISTANCE ...................... 435
11.17.1 General ............................................................... 435
11.17.2 Limitations ............................................................ 435
11.17.2.1 Exterior Escape balcony increase ......................... 435
11.17.2.2 Groups F-1 and S-1 increase .................................. 435

xlii
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.17.3</td>
<td>Measurement</td>
<td>436</td>
</tr>
<tr>
<td>11.18</td>
<td>AISLES</td>
<td>436</td>
</tr>
<tr>
<td>11.18.1</td>
<td>General</td>
<td>436</td>
</tr>
<tr>
<td>11.18.2</td>
<td>Aisles in assembly spaces</td>
<td>436</td>
</tr>
<tr>
<td>11.18.3</td>
<td>Aisles in Groups B and M</td>
<td>436</td>
</tr>
<tr>
<td>11.18.4</td>
<td>Aisle accessways in Group M</td>
<td>436</td>
</tr>
<tr>
<td>11.18.5</td>
<td>Aisles in other than assembly spaces and Groups B and M</td>
<td>436</td>
</tr>
<tr>
<td>11.19</td>
<td>EXIT ACCESS STAIRWAYS AND RAMPS</td>
<td>437</td>
</tr>
<tr>
<td>11.19.1</td>
<td>General</td>
<td>437</td>
</tr>
<tr>
<td>11.19.2</td>
<td>All occupancies</td>
<td>437</td>
</tr>
<tr>
<td>11.19.3</td>
<td>Occupancies other than Groups I-2 and I-3</td>
<td>437</td>
</tr>
<tr>
<td>11.19.4</td>
<td>Group I-2 and I-3 occupancies</td>
<td>437</td>
</tr>
<tr>
<td>11.20</td>
<td>CORRIDORS</td>
<td>437</td>
</tr>
<tr>
<td>11.20.1</td>
<td>Construction</td>
<td>437</td>
</tr>
<tr>
<td>11.20.1.1</td>
<td>Hoistway opening protection</td>
<td>438</td>
</tr>
<tr>
<td>11.20.2</td>
<td>Width and capacity</td>
<td>438</td>
</tr>
<tr>
<td>11.20.3</td>
<td>Obstruction</td>
<td>439</td>
</tr>
<tr>
<td>11.20.4</td>
<td>Dead ends</td>
<td>439</td>
</tr>
<tr>
<td>11.20.5</td>
<td>Air movement in corridors</td>
<td>439</td>
</tr>
<tr>
<td>11.20.6</td>
<td>Corridor continuity</td>
<td>439</td>
</tr>
<tr>
<td>11.21</td>
<td>ESCAPE BALCONIES</td>
<td>440</td>
</tr>
<tr>
<td>11.21.1</td>
<td>General</td>
<td>440</td>
</tr>
<tr>
<td>11.21.2</td>
<td>Wall separation</td>
<td>440</td>
</tr>
<tr>
<td>11.21.3</td>
<td>Openness</td>
<td>440</td>
</tr>
<tr>
<td>11.21.4</td>
<td>Location</td>
<td>440</td>
</tr>
<tr>
<td>11.22</td>
<td>EXITS</td>
<td>440</td>
</tr>
<tr>
<td>11.22.1</td>
<td>General</td>
<td>440</td>
</tr>
<tr>
<td>11.22.2</td>
<td>Exterior exit doors</td>
<td>440</td>
</tr>
<tr>
<td>11.22.2.1</td>
<td>Detailed requirements</td>
<td>440</td>
</tr>
<tr>
<td>11.22.2.2</td>
<td>Arrangement</td>
<td>440</td>
</tr>
<tr>
<td>11.23</td>
<td>INTERIOR EXIT STAIRWAYS AND RAMPS</td>
<td>440</td>
</tr>
<tr>
<td>11.23.1</td>
<td>General</td>
<td>440</td>
</tr>
<tr>
<td>11.23.2</td>
<td>Construction</td>
<td>441</td>
</tr>
<tr>
<td>11.23.3</td>
<td>Termination</td>
<td>441</td>
</tr>
<tr>
<td>11.23.3.1</td>
<td>Extension</td>
<td>441</td>
</tr>
<tr>
<td>11.23.4</td>
<td>Openings</td>
<td>441</td>
</tr>
<tr>
<td>11.23.6</td>
<td>Ventilation</td>
<td>442</td>
</tr>
<tr>
<td>11.23.7</td>
<td>Interior exit stairway and ramp exterior walls</td>
<td>442</td>
</tr>
<tr>
<td>11.23.8</td>
<td>Discharge identification</td>
<td>442</td>
</tr>
<tr>
<td>11.23.9</td>
<td>Stairway identification signs</td>
<td>442</td>
</tr>
<tr>
<td>11.23.9.1</td>
<td>Signage requirements</td>
<td>443</td>
</tr>
<tr>
<td>11.23.10</td>
<td>Elevator lobby identification signs</td>
<td>443</td>
</tr>
<tr>
<td>11.23.11</td>
<td>Smokeproof enclosures</td>
<td>443</td>
</tr>
<tr>
<td>11.23.11.2</td>
<td>Enclosure access</td>
<td>443</td>
</tr>
<tr>
<td>11.23.12</td>
<td>Standpipes</td>
<td>443</td>
</tr>
<tr>
<td>11.24</td>
<td>EXIT PASSAGEWAYS</td>
<td>443</td>
</tr>
<tr>
<td>11.24.1</td>
<td>Exit passageways</td>
<td>444</td>
</tr>
<tr>
<td>11.24.3</td>
<td>Construction</td>
<td>444</td>
</tr>
<tr>
<td>11.24.4</td>
<td>Termination</td>
<td>444</td>
</tr>
<tr>
<td>11.24.5</td>
<td>Openings</td>
<td>444</td>
</tr>
<tr>
<td>11.24.6</td>
<td>Penetrations</td>
<td>444</td>
</tr>
<tr>
<td>11.24.7</td>
<td>Ventilation</td>
<td>444</td>
</tr>
<tr>
<td>11.24.8</td>
<td>Fire Hydrant</td>
<td>445</td>
</tr>
<tr>
<td>11.25</td>
<td>LUMINOUS ESCAPE PATH MARKINGS</td>
<td>445</td>
</tr>
<tr>
<td>11.25.1</td>
<td>General</td>
<td>445</td>
</tr>
<tr>
<td>11.25.2</td>
<td>Markings within exit components</td>
<td>445</td>
</tr>
<tr>
<td>11.25.2.1</td>
<td>Steps</td>
<td>445</td>
</tr>
<tr>
<td>11.25.2.2</td>
<td>Landings</td>
<td>445</td>
</tr>
<tr>
<td>11.25.2.3</td>
<td>Handrails</td>
<td>445</td>
</tr>
<tr>
<td>11.25.2.4</td>
<td>Perimeter demarcation lines</td>
<td>445</td>
</tr>
</tbody>
</table>
11.25.2.4.2 Wall-mounted demarcation lines
11.25.2.4.3 Transition
11.25.2.5 Obstacles
11.25.2.6 Doors within the exit path
11.25.2.6.1 Emergency exit symbol
11.25.2.6.2 Door hardware markings
11.25.2.6.3 Door frame markings
11.25.3 Uniformity
11.25.4 Self-luminous and photoluminescent
11.25.5 Illumination
11.26 HORIZONTAL EXITS
11.26.1 Horizontal exits
11.26.2 Separation
11.26.3 Opening protective
11.26.4 Refuge area
11.26.4.1 Capacity
11.26.4.2 Number of exits
11.26.5 Standpipes
11.27 EXTERIOR EXIT STAIRWAYS AND RAMPS
11.27.1 Exterior exit stairways and ramps
11.27.2 Use in a means of Escape
11.27.3 Open side
11.27.5 Location
11.27.6 Exterior exit stairway and ramp protection
11.28 FINAL EXIT
11.28.1 General
11.28.2 Exit discharge width or capacity
11.28.3 Exit discharge components
11.28.4.1 Width or capacity
11.28.4.2 Construction and openings
11.28.5 Access to a public way
11.29 ASSEMBLY
11.29.1 General
11.29.1.1 Bleachers
11.29.1.1.1 Spaces under grandstands and bleachers
11.29.2 Assembly main exit
11.29.3 Assembly other exits
11.29.4 Foyers and lobbies
11.29.5 Interior balcony and gallery means of escape
11.29.6 Capacity of aisle for assembly
11.29.6.1 Without smoke protection
11.29.6.2 Smoke-protected assembly seating
11.29.6.2.1 Smoke control
11.29.6.2.2 Roof height
11.29.6.2.3 Automatic sprinklers
11.29.6.3 Open-air assembly seating
11.29.7 Travel distance
11.29.8 Common path of Escape travel
11.29.8.1 Path through adjacent row
11.29.9 Assembly aisles are required
11.29.9.1 Minimum aisle width
11.29.9.2 Aisle catchment area
11.29.9.3 Converging aisles
11.29.9.4 Uniform width and capacity
11.29.9.5 Dead-end aisles
11.29.9.6 Aisle measurement
11.29.9.6.1 Assembly aisle obstructions
11.29.9.7 Stairways connecting to stepped aisles
11.29.9.8 Stairways connecting to vomitories
11.29.10 Transitions
11.29.10.1 Transitions to stairways that maintain stepped aisle riser and tread dimensions
11.29.10.2 Transitions to stairways that do not maintain stepped aisle riser and tread dimensions.... 456
11.29.10.2.1 Stairways and stepped aisles in a straight run .................................................. 456
11.29.10.2.2 Stairways that change direction from stepped aisles ......................................... 456
11.29.10.3 Transition marking .................................................................................................. 456
11.29.11 Stepped aisles at vomitories ..................................................................................... 456
11.29.11.1 Stepped aisles that change direction at vomitories .................................................. 456
11.29.11.2 Stepped aisle transitions at the top of vomitories .................................................... 456
11.29.12 Construction .............................................................................................................. 456
11.29.12.1 Walking surface ....................................................................................................... 456
11.29.12.2 Outdoor conditions ................................................................................................. 457
11.29.13 Aisle accessways ....................................................................................................... 457
11.29.13.1 Seating at tables ...................................................................................................... 457
11.29.13.1.1 Aisle accessway capacity and width for seating at tables ..................................... 457
11.29.13.1.2 Seating at table aisle accessway length ............................................................... 457
11.29.13.2 Clear width of aisle accessways serving seating in rows ......................................... 457
11.29.13.2.1 Dual access ........................................................................................................... 457
11.29.13.2.2 Single access ........................................................................................................ 458
11.29.14.1 Ramped aisles ........................................................................................................ 458
11.29.14.1.1 Cross slope ........................................................................................................... 458
11.29.14.1.2 Landings .............................................................................................................. 458
11.29.14.1.3 Edge protection .................................................................................................... 458
11.29.14.2 Stepped aisles ........................................................................................................ 458
11.29.14.2.1 Treads ................................................................................................................ 458
11.29.14.2.2 Risers ................................................................................................................ 459
11.29.14.2.2.1 Construction tolerances ................................................................................... 459
11.29.14.2.3 Tread contrasting marking stripe ........................................................................ 459
11.29.14.2.4 Nosing and profile .............................................................................................. 459
11.29.15 Seat stability .............................................................................................................. 459
11.29.16 Handrails .................................................................................................................. 460
11.29.16.1 Discontinuous handrails ......................................................................................... 460
11.29.16.2 Handrail termination ............................................................................................. 460
11.29.16.3 Mid-aisle termination ............................................................................................. 460
11.29.16.4 Rails ....................................................................................................................... 460
11.29.17 Assembly guards ...................................................................................................... 460
11.29.17.1 Perimeter guards ................................................................................................... 460
11.29.17.2 Cross aisles ........................................................................................................... 461
11.29.17.3 Sightline-constrained guard heights ....................................................................... 461
11.29.17.4 Guards at the end of aisles ..................................................................................... 461
11.30 EMERGENCY ESCAPE AND RESCUE ..................................................................... 461
11.30.1 General ....................................................................................................................... 461
11.30.1.1 Operational constraints and opening control devices ............................................. 462
11.30.2 Minimum size ............................................................................................................ 462
11.30.2.1 Minimum dimensions ............................................................................................. 462
11.30.3 Maximum height from floor ....................................................................................... 462
11.30.4 Window wells ............................................................................................................. 462
11.30.4.1 Minimum size .......................................................................................................... 462
11.30.4.2 Ladders or steps ....................................................................................................... 462
11.30.5 Bars, grilles, covers and screens ............................................................................... 462
PART 12: ACCESSIBILITY .................................................................................................... 463
PART 13: INTERIOR ENVIRONMENT .................................................................................... 464
13.1 GENERAL ......................................................................................................................... 464
13.1.1 Scope .......................................................................................................................... 464
13.1.2 Indoor air quality management plan required ............................................................... 464
13.2 BUILDING CONSTRUCTION FEATURES, OPERATIONS AND MAINTENANCE FACILITATION ................................................................. 464
13.2.1 Scope .......................................................................................................................... 464
13.2.2 Air-handling system access ......................................................................................... 464
13.2.3 Air-handling filtration and bypass pathways .............................................................. 464
13.3 HVAC SYSTEMS ............................................................................................................ 464
13.3.1 Construction phase requirements ............................................................................... 464
13.3.1.1 Duct openings ........................................................................................................ 464
13.3.1.2 Indoor air quality during construction ................................................................. 465
13.3.1.2.1 Ventilation ........................................................................................................ 465
13.3.1.2.2 Protection of HVAC system openings ............................................................ 465
13.3.1.2.3 Return air filters ............................................................................................... 465
13.3.1.3 Construction phase ductless system or filter ...................................................... 465
13.3.2 Thermal environmental conditions for human occupancy ....................................... 465
13.3.3 Isolation of pollutant sources .................................................................................. 465
13.3.3.1 Printer, copier and janitorial rooms ..................................................................... 465
13.3.4 Filters ....................................................................................................................... 466
13.4 SPECIFIC INDOOR AIR QUALITY AND POLLUTANT CONTROL MEASURES ..................... 466
13.4.1 Fireplaces and appliances ....................................................................................... 466
13.4.1.1 Venting and combustion air ................................................................................ 466
13.4.1.2 Wood-fired appliances ....................................................................................... 466
13.4.1.3 Biomass appliances ........................................................................................... 466
13.4.2 Post-construction, pre-occupancy baseline IAQ testing ....................................... 466
13.5 PROHIBITED MATERIALS ......................................................................................... 467
13.5.1 Scope ....................................................................................................................... 467
13.6 MATERIAL EMISSIONS AND POLLUTANT CONTROL .................................................. 467
13.6.1 Emissions from composite wood products ............................................................. 468
13.6.2 Adhesives and sealants ......................................................................................... 468
13.6.3 Floor coverings ...................................................................................................... 469
13.6.4 Flooring ................................................................................................................. 470
13.6.5 Acoustical ceiling tiles and wall systems ............................................................... 471
13.7 ACOUSTICS ............................................................................................................... 471
13.7.1 Sound transmission and sound levels .................................................................... 471
13.7.2 Sound transmission ............................................................................................... 472
13.7.2.1 Interior sound transmission .............................................................................. 472
13.7.2.2 Mechanical and emergency generator equipment and systems ...................... 472
13.7.3 Sound levels ......................................................................................................... 472
13.7.3.1 Sound of mechanical and electrical generator equipment outside of buildings 472
13.7.3.2 Sound of HVAC and mechanical systems within buildings ............................. 473
13.7.4 Structure-borne sounds ......................................................................................... 474
13.7.5 Commissioning for sound levels .......................................................................... 474
13.7.5.1 Testing for mechanical and electrical generator equipment outside of buildings 474
13.7.5.2 Testing for building system background noise ............................................... 474
13.8 DAYLIGHTING ......................................................................................................... 474
13.8.1 General .................................................................................................................. 474
13.8.1.1 Fenestration obstructions ................................................................................. 474
13.8.2 Applicability ......................................................................................................... 474
13.8.3 Daylit area of building spaces .............................................................................. 475
13.8.3.1 Daylight prescriptive requirements ................................................................ 475
13.8.3.2 Daylight performance path ............................................................................. 476
13.8.3.2.1 Morning illumination .................................................................................... 476
13.8.3.2.2 Afternoon illumination ................................................................................. 476
13.8.3.2.3 Daylight analysis .......................................................................................... 476
13.8.4 Sky types .............................................................................................................. 477
13.8.4.1 United States sky types .................................................................................... 477
13.8.4.2 International sky types ..................................................................................... 477
13.9 VENTILATION .......................................................................................................... 477
13.9.1 General .................................................................................................................. 477
13.9.2 Roof ventilation .................................................................................................... 477
13.9.2.1 Ventilated attics and rafter spaces .................................................................... 477
13.9.2.2 Openings into attic ........................................................................................... 478
13.9.3 Unvented attic and unvented enclosed rafter assemblies ..................................... 478
13.9.4 Under-floor ventilation ......................................................................................... 479
13.9.4.1 Ventilation openings ........................................................................................ 479
13.9.4.1.1 Ventilation area for crawl spaces with open earth floors .......................... 479
13.9.4.1.2 Ventilation area for crawl spaces with covered floors ................................ 480
13.9.4.2 Ventilation in cold climates .............................................................................. 480
13.9.4.3 Mechanical ventilation ..................................................................................... 480
13.9.4.3.1 Continuous mechanical ventilation ............................................................... 480
13.9.4.3.2 Conditioned space ........................................................................................ 480
13.9.4.4 Flood hazard areas ................................................................. 480
13.9.5 Natural ventilation ................................................................. 480
13.9.5.1 Ventilation area required .................................................. 480
13.9.5.1.1 Adjoining spaces ......................................................... 480
13.9.5.1.2 Openings below grade ............................................... 480
13.9.5.2 Contaminants exhausted ................................................ 480
13.9.5.2.1 Bathrooms ............................................................... 480
13.9.5.3 Openings on yards or courts .......................................... 481
13.9.6 Other ventilation and exhaust systems .................................. 481
13.10 TEMPERATURE CONTROL .......................................................... 481
13.10.1 Equipment and systems ..................................................... 481
13.11 LIGHTING .............................................................................. 481
13.11.1 General ................................................................................. 481
13.11.2 Natural light .......................................................................... 481
13.11.2.1 Adjoining spaces .......................................................... 481
13.11.2.2 Exterior openings .......................................................... 481
13.11.3 Artificial light ......................................................................... 481
13.11.4.1 Controls ........................................................................... 481
13.11.4.2.1 Furred ceiling ............................................................ 481
13.11.4.2 Minimum ceiling heights .............................................. 482
13.11.4.2.2 Exterior openings ....................................................... 482
13.11.4.3 Stairway illumination ........................................................ 481
13.11.4.4.1 Controls ...................................................................... 482
13.11.5 Emergency egress lighting ................................................ 482
13.12 YARDS OR COURTS ................................................................. 482
13.12.1 General ................................................................................. 482
13.12.2 Yards .................................................................................... 482
13.12.3 Courts .................................................................................. 482
13.12.3.1 Court access ................................................................. 482
13.12.3.2 Air intake ........................................................................ 482
13.12.3.3 Court drainage ............................................................... 482
13.13 SOUND TRANSMISSION ............................................................ 482
13.13.1 Scope ..................................................................................... 482
13.13.2 Airborne sound ................................................................. 482
13.13.2.1 Masonry ......................................................................... 482
13.13.3 Structure-borne sound ....................................................... 482
13.14 INTERIOR SPACE DIMENSIONS .............................................. 483
13.14.1 Minimum room widths ...................................................... 483
13.14.2 Minimum ceiling heights .................................................... 483
13.14.2.1 Furred ceiling ............................................................... 483
13.14.3 Room area ........................................................................... 483
13.14.3.4 Wall layouts ................................................................. 483
13.14.4 Efficiency dwelling units .................................................. 483
13.15 ACCESS TO UNOCCUPIED SPACES ........................................ 484
13.15.1 Crawl spaces ...................................................................... 484
13.15.2 Attic spaces ......................................................................... 484
13.15.3 Mechanical appliances .................................................... 484
13.16 TOILET AND BATHROOM REQUIREMENTS .............................. 484
13.16.1 Required fixtures ............................................................... 484
13.16.2 Finish materials ................................................................. 484
13.16.2.1 Floors and wall bases ..................................................... 484
13.16.2.2 Walls and partitions ....................................................... 484
13.16.2.3 Showers ......................................................................... 484
13.16.2.4 Waterproof joints ........................................................... 484
13.16.3 Privacy ................................................................................ 484
13.16.3.1 Water closet compartment .......................................... 484
13.16.3.2 Urinal partitions .............................................................. 485
PART 14: ENERGY EFFICIENCY AND SUSTAINABILITY ............... 486
14.1 SCOPE ....................................................................................... 486
14.1.2 Performance Requirements ................................................ 486
14.2 MECHANICAL VENTILATION SYSTEMS ...................................... 486
14.2.1 General requirements ........................................................ 486
14.3 REFRIGERATION EQUIPMENT AND APPLIANCES ..................... 486
14.4 HOT WATER ............................................................................ 486
14.4.2 Fuel source .......................................................................... 487
14.4.3 Solar heating ......................................................................... 487
15.4.10.1.4.1 Lathing. .................................................. 496
15.4.10.1.4.2 Scratch coat. ........................................... 496
15.4.10.1.4.3 Adhering veneer ...................................... 496
15.4.10.1.5 Adhered masonry veneer applied directly to masonry and concrete .... 497
15.4.10.1.6 Cold weather construction. ......................... 497
15.4.10.1.7 Hot weather construction. .......................... 497
15.4.10.2 Exterior adhered masonry veneers—porcelain tile. ....... 497
15.4.10.3 Interior adhered masonry veneers. ..................... 497
15.4.11 Metal veneers .................................................. 497
15.4.11.1 Attachment ................................................ 497
15.4.11.2 Weather protection ...................................... 497
15.4.11.3 Backup .................................................... 497
15.4.11.4 Grounding ................................................ 497
15.4.12 Glass veneer .................................................. 497
15.4.12.1 Length and height. ....................................... 497
15.4.12.2 Thickness ................................................. 498
15.4.12.3 Application ................................................ 498
15.4.12.4 Installation at sidewalk level. ......................... 498
15.4.12.4.1 Installation above sidewalk level ................ 498
15.4.12.5 Joints ..................................................... 498
15.4.12.6 Mechanical fastenings ................................ 498
15.4.12.6.1.1 Fire separat...
15.6.11.2.2 Limitations. ............................................................... 503
15.6.11.3 Installations up to 75 feet in height (Option 1). ......................... 503
15.6.11.3.1 Prohibited occupancies ............................................... 503
15.6.11.3.2 Non-fire-resistance-rated exterior walls. ................................. 503
15.6.11.3.3 Specifications. ............................................................ 503
15.6.11.3.4 Area limitation and separation. ...................................... 503
15.6.11.3.5 Automatic sprinkler system increases ................................ 504
15.6.11.4 Installations up to 75 feet in height (Option 2). ......................... 504
15.6.11.4.1 Minimum fire separation distance. .................................... 504
15.6.11.4.2 Specifications .................................................................. 505
15.6.11.4.3 Area and size limitations ................................................ 505
15.6.11.4.4 Vertical separations. ....................................................... 505
15.6.13 Foam plastic insulation. ......................................................... 505
15.6.14 Labeling. ............................................................................ 505
15.7 EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS) .................. 505
15.7.1 General. .............................................................................. 505
15.7.2 Performance characteristics. ..................................................... 505
15.7.3 Structural design. ................................................................... 505
15.7.4 Weather resistance. ............................................................... 505
15.7.4.1 EIFS with drainage. ................................................................. 505
15.7.4.1.1 Water-resistive barrier. ....................................................... 505
15.7.5 Installation .............................................................. 505
15.7.6 Special inspections. ............................................................... 506
15.8 HIGH-PRESSURE DECORATIVE EXTERIOR-GRÁDE COMPACT LAMINATES (HPL) ................................. 506
15.8.1 General. .............................................................. 506
15.8.2 Exterior wall finish. ............................................................... 506
15.8.3 Architectural trim and embellishments. ........................................ 506
15.8.4 Structural design. ............................................................... 506
15.8.5 Approval. .............................................................. 506
15.8.6 Weather resistance. ............................................................... 506
15.8.7 Durability. .............................................................. 506
15.8.8 Fire-resistance rating. ............................................................. 506
15.8.9 Surface-burning characteristics. ................................................ 506
15.8.10 Type I, II and III construction .................................................. 506
15.8.10.1 Surface-burning characteristics ................................................ 506
15.8.10.2 Thermal barriers ................................................................. 506
15.8.10.3 Thermal barrier not required. ............................................... 506
15.8.10.4 Full-scale tests. ................................................................. 507
15.8.11 Alternate conditions. ............................................................. 507
15.8.11.1 Installations up to 40 feet in height. ........................................ 507
15.8.11.1.1 Fire separation distance of 5 feet or less. ............................. 507
15.8.11.1.2 Fire separation distance greater than 5 feet. ......................... 507
15.8.11.2 Installations up to 50 feet in height. ........................................ 507
15.8.11.2.1 Self-ignition temperature .................................................. 507
15.8.11.2.2 Limitations. ................................................................. 507
15.8.13 Foam plastic insulation. ........................................................ 507
15.8.14 Labeling. .............................................................. 507
15.9 PLASTIC COMPOSITE DECKING ............................................ 507
15.10 BUILDING ENVELOPE SYSTEMS .......................................... 507
15.10.1 Prescriptive compliance. ....................................................... 507
15.10.1.1 Insulation and fenestration criteria ........................................ 507
15.10.1.1.1 Shading devices for fenestration ......................................... 507
15.10.1.2 Air leakage. .............................................................. 508
15.10.1.2.1 Air barriers ................................................................. 508
15.10.1.2.2 Testing requirement. ......................................................... 508
15.10.1.2.3 Air curtains. ............................................................... 509
PART 16: ROOF ASSEMBLIES AND ROOFTOP STRUCTURES ........................................ 510
16.1 GENERAL .............................................................. 510
16.1.1 Scope. .............................................................. 510
16.2 ROOF DRAINAGE ........................................................... 510
16.2.1 General. .............................................................. 510
16.2.2 Secondary (emergency overflow) drains or scuppers. ............................................................... 510
16.2.3 Scuppers ........................................................................................................................................ 510
16.2.4 Gutters ........................................................................................................................................... 510
16.3 WEATHER PROTECTION .................................................................................................................... 510
16.3.1 General ........................................................................................................................................... 510
16.3.2 Flashing .......................................................................................................................................... 510
16.3.2.1 Locations .................................................................................................................................... 510
16.3.3 Coping ............................................................................................................................................ 510
16.3.4 Attic and rafter ventilation. ............................................................................................................... 510
16.3.5 Crickets and saddles ....................................................................................................................... 510
16.4 PERFORMANCE REQUIREMENTS .................................................................................................... 511
16.4.1 Wind resistance of roofs ................................................................................................................ 511
16.4.1.1 Wind resistance of asphalt shingles ......................................................................................... 511
16.4.2 Wind resistance of clay and concrete tile ..................................................................................... 511
16.4.2.1 Testing ....................................................................................................................................... 511
16.4.2.1.1 Overturning resistance ........................................................................................................... 511
16.4.2.1.2 Wind tunnel testing ................................................................................................................ 511
16.4.3 Wind resistance of nonballasted roofs ........................................................................................... 511
16.4.3.1 Other roof systems ..................................................................................................................... 511
16.4.3.2 Structural metal panel roof systems .......................................................................................... 511
16.4.3.3 Metal roof shingles ..................................................................................................................... 511
16.4.4 Ballasted low-slope roof systems .................................................................................................... 512
16.4.4.1 Fire retardant-treated wood shingles and shakes ................................................................. 512
16.4.6 Physical properties ........................................................................................................................ 512
16.4.7 Impact resistance ............................................................................................................................ 512
16.5 FIRE CLASSIFICATION ..................................................................................................................... 512
16.5.1 General ........................................................................................................................................... 512
16.5.2 Class A roof assemblies ................................................................................................................ 512
16.5.3 Class B roof assemblies ................................................................................................................ 513
16.5.4 Class C roof assemblies ................................................................................................................ 513
16.5.5 Nonclassified roofing ..................................................................................................................... 513
16.5.6 Fire-retardant-treated wood shingles and shakes ........................................................................ 513
16.5.7 Special purpose roofs .................................................................................................................... 513
16.5.8 Building-integrated photovoltaic products .................................................................................... 513
16.5.9 Rooftop mounted photovoltaic panel systems .............................................................................. 513
16.5.10 Roof gardens and landscaped roofs ............................................................................................ 513
16.6 MATERIALS ........................................................................................................................................ 513
16.6.1 Scope ............................................................................................................................................ 513
16.6.2 Material specifications and physical characteristics ....................................................................... 513
16.6.3 Product identification .................................................................................................................... 514
16.7 REQUIREMENTS FOR ROOF COVERINGS ................................................................................ 514
16.7.1 Scope ............................................................................................................................................ 514
16.7.1.1 Underlayment ........................................................................................................................... 514
16.7.2 Asphalt shingles ............................................................................................................................. 517
16.7.2.1 Deck requirements .................................................................................................................... 517
16.7.2.2 Slope .......................................................................................................................................... 517
16.7.2.3 Underlayment ........................................................................................................................... 517
16.7.2.4 Asphalt shingles ........................................................................................................................ 517
16.7.2.5 Fasteners .................................................................................................................................. 518
16.7.2.6 Attachment ................................................................................................................................ 518
16.7.2.8 Flashings .................................................................................................................................... 518
16.7.2.8.1 Base and cap flashing ............................................................................................................ 518
16.7.2.8.2 Valleys ..................................................................................................................................... 518
16.7.2.8.3 Drip edge ................................................................................................................................. 519
16.7.3 Clay and concrete tile ..................................................................................................................... 519
16.7.3.1 Deck requirements .................................................................................................................... 519
16.7.3.2 Deck slope ................................................................................................................................ 519
16.7.3.3 Underlayment ........................................................................................................................... 519
16.7.3.4 Clay tile ..................................................................................................................................... 519
16.7.3.5 Concrete tile .............................................................................................................................. 519
16.7.3.6 Fasteners .................................................................................................................................. 519
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.7.3.7</td>
<td>Attachment</td>
<td>519</td>
</tr>
<tr>
<td>16.7.2.8.3</td>
<td>Drip edge</td>
<td>519</td>
</tr>
<tr>
<td>16.7.3</td>
<td>Clay and concrete tile</td>
<td>519</td>
</tr>
<tr>
<td>16.7.3.1</td>
<td>Deck requirements</td>
<td>519</td>
</tr>
<tr>
<td>16.7.3.2</td>
<td>Deck slope</td>
<td>519</td>
</tr>
<tr>
<td>16.7.3.3</td>
<td>Underlayment</td>
<td>520</td>
</tr>
<tr>
<td>16.7.3.4</td>
<td>Clay tile</td>
<td>520</td>
</tr>
<tr>
<td>16.7.3.5</td>
<td>Concrete tile</td>
<td>520</td>
</tr>
<tr>
<td>16.7.3.6</td>
<td>Fasteners</td>
<td>520</td>
</tr>
<tr>
<td>16.7.3.7</td>
<td>Attachment</td>
<td>520</td>
</tr>
<tr>
<td>16.7.3.8</td>
<td>Application</td>
<td>521</td>
</tr>
<tr>
<td>16.7.3.9</td>
<td>Flashing</td>
<td>521</td>
</tr>
<tr>
<td>16.7.4</td>
<td>Metal roof panels</td>
<td>521</td>
</tr>
<tr>
<td>16.7.4.1</td>
<td>Deck requirements</td>
<td>521</td>
</tr>
<tr>
<td>16.7.4.2</td>
<td>Deck slope</td>
<td>521</td>
</tr>
<tr>
<td>16.7.4.3</td>
<td>Material standards</td>
<td>521</td>
</tr>
<tr>
<td>16.7.4.4</td>
<td>Attachment</td>
<td>522</td>
</tr>
<tr>
<td>16.7.4.5</td>
<td>Underlayment and high wind</td>
<td>522</td>
</tr>
<tr>
<td>16.7.5</td>
<td>Metal roof shingles</td>
<td>522</td>
</tr>
<tr>
<td>16.7.5.1</td>
<td>Deck requirements</td>
<td>522</td>
</tr>
<tr>
<td>16.7.5.2</td>
<td>Deck slope</td>
<td>522</td>
</tr>
<tr>
<td>16.7.5.3</td>
<td>Underlayment</td>
<td>522</td>
</tr>
<tr>
<td>16.7.5.5</td>
<td>Material standards</td>
<td>522</td>
</tr>
<tr>
<td>16.7.5.6</td>
<td>Attachment</td>
<td>523</td>
</tr>
<tr>
<td>16.7.5.7</td>
<td>Flashing</td>
<td>523</td>
</tr>
<tr>
<td>16.7.6</td>
<td>Mineral-surfaced roll roofing</td>
<td>523</td>
</tr>
<tr>
<td>16.7.6.1</td>
<td>Deck requirements</td>
<td>523</td>
</tr>
<tr>
<td>16.7.6.2</td>
<td>Deck slope</td>
<td>523</td>
</tr>
<tr>
<td>16.7.6.3</td>
<td>Underlayment</td>
<td>523</td>
</tr>
<tr>
<td>16.7.6.5</td>
<td>Material standards</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7</td>
<td>Slate shingles</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7.1</td>
<td>Deck requirements</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7.2</td>
<td>Deck slope</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7.3</td>
<td>Underlayment</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7.5</td>
<td>Material standards</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7.6</td>
<td>Application</td>
<td>523</td>
</tr>
<tr>
<td>16.7.7.7</td>
<td>Flashing</td>
<td>523</td>
</tr>
<tr>
<td>16.7.8</td>
<td>Wood shingles</td>
<td>523</td>
</tr>
<tr>
<td>16.7.8.1</td>
<td>Deck requirements</td>
<td>524</td>
</tr>
<tr>
<td>16.7.8.1.1</td>
<td>Solid sheathing</td>
<td>524</td>
</tr>
<tr>
<td>16.7.8.2</td>
<td>Deck slope</td>
<td>524</td>
</tr>
<tr>
<td>16.7.8.3</td>
<td>Underlayment</td>
<td>524</td>
</tr>
<tr>
<td>16.7.8.5</td>
<td>Material standards</td>
<td>524</td>
</tr>
<tr>
<td>16.7.8.6</td>
<td>Attachment</td>
<td>525</td>
</tr>
<tr>
<td>16.7.8.7</td>
<td>Application</td>
<td>525</td>
</tr>
<tr>
<td>16.7.8.8</td>
<td>Flashing</td>
<td>526</td>
</tr>
<tr>
<td>16.7.8.9</td>
<td>Label required</td>
<td>526</td>
</tr>
<tr>
<td>16.7.10</td>
<td>Built-up roofs</td>
<td>526</td>
</tr>
<tr>
<td>16.7.10.1</td>
<td>Slope</td>
<td>526</td>
</tr>
<tr>
<td>16.7.10.2</td>
<td>Material standards</td>
<td>526</td>
</tr>
<tr>
<td>16.7.11</td>
<td>Modified bitumen roofing</td>
<td>526</td>
</tr>
<tr>
<td>16.7.11.1</td>
<td>Slope</td>
<td>526</td>
</tr>
<tr>
<td>16.7.11.2</td>
<td>Material standards</td>
<td>526</td>
</tr>
<tr>
<td>16.7.11.2.1</td>
<td>Base sheet</td>
<td>527</td>
</tr>
<tr>
<td>16.7.12</td>
<td>Thermoset single-ply roofing</td>
<td>527</td>
</tr>
<tr>
<td>16.7.12.1</td>
<td>Slope</td>
<td>527</td>
</tr>
<tr>
<td>16.7.12.2</td>
<td>Material standards</td>
<td>527</td>
</tr>
<tr>
<td>16.7.12.3</td>
<td>Ballasted thermoset low-slope roofs</td>
<td>527</td>
</tr>
<tr>
<td>16.7.13</td>
<td>Thermoplastic single-ply roofing</td>
<td>527</td>
</tr>
<tr>
<td>16.7.13.1</td>
<td>Slope</td>
<td>527</td>
</tr>
<tr>
<td>16.7.13.2</td>
<td>Material standards</td>
<td>527</td>
</tr>
</tbody>
</table>
16.10.8 Other rooftop structures.

16.10.5.2 Towers and spires.

16.10.5.1 Noncombustible construction required.

16.10.4 Cooling towers.

16.10.3.3 Tank cover.

16.10.3

16.10.2.4 Type of construction.

16.10.2.3 Weather protection.

16.10 ROOFTOP STRUCTURES

16.9.4 Material standards.

16.9.3 Installation.

16.9.1 General.

16.8.2 Material standards.

16.8.1 General.

16.8.2.4 Material standards.

16.8.1 Radiant barriers installed above deck.

16.7.14.3 Application.


16.7.14.1 Slope.

16.7.14 Sprayed polyurethane foam roofing.

16.7.13.3 Ballasted thermoplastic low-slope roofs.

16.7.12 Mechanical equipment screens.

16.7.11 Wind resistance.

16.7.10 Photovoltaic shingles.

16.7.9 Slope roofs.

16.7.8 Wind resistance.

16.7.7.6 Material standards.

16.7.7.5 Fasteners.

16.7.7.4 Wind resistance.

16.7.7.3 Underlayment.

16.7.7.2 Deck slope.

16.7.7.1 Deck requirements.

16.7.6 Material standards.

16.7.5.3 Tank test.

16.7.5.2 Tank cover.

16.7.5.1 Tank installation.

16.7.5.0 Tank design.

16.7.4 Material standards.

16.7.3 Installation.

16.7.2.4 Type of construction.

16.7.2.3 Weather protection.

16.7.2.2 Use limitations.

16.7.2.1 Height above roof deck.

16.7.2.0 General.

16.7.17 Photovoltaic shingles.

16.7.16 Vegetative roofs, roof gardens and landscaped roofs.

16.7.15 Liquid-applied roofing.

16.7.14.1 Slope.


16.7.14.3 Application.

16.7.14.4 Foam plastics.

16.7.13.5 Tank test.

16.7.13.4 Tank installation.

16.7.13.3 Ballasted thermoplastic low-slope roofs.

16.7.12 Mechanical equipment screens.

16.7.11 Wind resistance.

16.7.10 Photovoltaic shingles.

16.7.9 Slope roofs.

16.7.8 Wind resistance.

16.7.7.6 Material standards.

16.7.7.5 Fasteners.

16.7.7.4 Wind resistance.

16.7.7.3 Underlayment.

16.7.7.2 Deck slope.

16.7.7.1 Deck requirements.

16.7.6 Material standards.

16.7.5.3 Tank test.

16.7.5.2 Tank cover.

16.7.5.1 Tank installation.

16.7.5.0 Tank design.

16.7.4 Material standards.

16.7.3 Installation.

16.7.2.4 Type of construction.

16.7.2.3 Weather protection.

16.7.2.2 Use limitations.

16.7.2.1 Height above roof deck.

16.7.2.0 General.

16.7.17 Photovoltaic shingles.

16.7.16 Vegetative roofs, roof gardens and landscaped roofs.

16.7.15 Liquid-applied roofing.

16.7.14.1 Slope.


16.7.14.3 Application.

16.7.14.4 Foam plastics.

16.7.13.5 Tank test.

16.7.13.4 Tank installation.

16.7.13.3 Ballasted thermoplastic low-slope roofs.

16.7.12 Mechanical equipment screens.

16.7.11 Wind resistance.

16.7.10 Photovoltaic shingles.

16.7.9 Slope roofs.

16.7.8 Wind resistance.

16.7.7.6 Material standards.

16.7.7.5 Fasteners.

16.7.7.4 Wind resistance.

16.7.7.3 Underlayment.

16.7.7.2 Deck slope.

16.7.7.1 Deck requirements.

16.7.6 Material standards.

16.7.5.3 Tank test.

16.7.5.2 Tank cover.

16.7.5.1 Tank installation.

16.7.5.0 Tank design.

16.7.4 Material standards.

16.7.3 Installation.

16.7.2.4 Type of construction.

16.7.2.3 Weather protection.

16.7.2.2 Use limitations.

16.7.2.1 Height above roof deck.

16.7.2.0 General.

16.7.17 Photovoltaic shingles.

16.7.16 Vegetative roofs, roof gardens and landscaped roofs.

16.7.15 Liquid-applied roofing.

16.7.14.1 Slope.


16.7.14.3 Application.

16.7.14.4 Foam plastics.

16.7.13.5 Tank test.

16.7.13.4 Tank installation.

16.7.13.3 Ballasted thermoplastic low-slope roofs.

16.7.12 Mechanical equipment screens.

16.7.11 Wind resistance.

16.7.10 Photovoltaic shingles.

16.7.9 Slope roofs.

16.7.8 Wind resistance.

16.7.7.6 Material standards.

16.7.7.5 Fasteners.

16.7.7.4 Wind resistance.

16.7.7.3 Underlayment.

16.7.7.2 Deck slope.

16.7.7.1 Deck requirements.

16.7.6 Material standards.

16.7.5.3 Tank test.

16.7.5.2 Tank cover.

16.7.5.1 Tank installation.

16.7.5.0 Tank design.

16.7.4 Material standards.

16.7.3 Installation.

16.7.2.4 Type of construction.

16.7.2.3 Weather protection.

16.7.2.2 Use limitations.

16.7.2.1 Height above roof deck.

16.7.2.0 General.

16.7.17 Photovoltaic shingles.

16.7.16 Vegetative roofs, roof gardens and landscaped roofs.

16.7.15 Liquid-applied roofing.

16.7.14.1 Slope.


16.7.14.3 Application.

16.7.14.4 Foam plastics.

16.7.13.5 Tank test.

16.7.13.4 Tank installation.

16.7.13.3 Ballasted thermoplastic low-slope roofs.
# Table of Contents

17.10.4.1 Basic data ................................................. 533
17.10.3.1 Reliability Differentiation .......................... 533
17.9.8 Force Coefficients \( f \) .................................. 533
17.8.4 (1) Loads on Railings ................................... 534

## PART 17: STRUCTURAL LOADS AND DESIGN

17.12.1 Photovoltaic panels and modules .................. 536

### 17.1 SCENE

17.1.2 This part of the Code does not cover .................. 536

### 17.2 DESIGN REQUIREMENTS

17.2.2 Design Basis ........................................... 536
17.2.3 Deflections ............................................. 536

### 17.3 CONSTRUCTION DOCUMENTS

17.3.1 General .................................................. 537
17.3.1.1 Floor live load ...................................... 537
17.3.1.2 Roof live load ....................................... 538

### 17.4 DESIGN LOADS AND EFFECTS

17.5 LIMIT STATE DESIGN .................................... 539
17.5.2 Methods of Limit State Design ....................... 540
17.5.2.1 Ghana, British System GS (BS 8110: Part 1) .... 540
17.5.2.1.1 Required Strength for Ultimate Limit State . 540
17.5.2.1.2 Values for a Serviceability Limit State ....... 541
17.5.2.2 EuroCode System GS (BS EN 1990, BS EN 1991, BS EN 1992) ........................................... 541
17.5.2.2.1 Required strength for Ultimate Limit State . 541
17.5.2.2.2 Values for Serviceability Limit State ....... 543

### 17.6 DEAD LOADS .............................................. 544

### 17.7 LIVE (IMPOSED) LOADS DUE TO USE AND OCCUPANCY

17.7.2 Floor Live Loads ........................................ 544
17.7.3 Reduction in Total Imposed Floor Loads ............ 545
17.7.4 Roof Live Loads other than Wind Loads or Rain Loads .............. 545

### 17.8 DYNAMIC LOADING ..................................... 549
17.8.4 (1) Loads on Railings ................................... 550

### 17.9 EFFECTS OF WIND ...................................... 551

17.3.1 Scope .................................................... 551
17.3.2 Definitions .............................................. 551
17.3.3 Nomenclature ........................................... 551
17.3.4 Procedure for calculating Wind Loads on Structures .............. 552
17.9.5 Design Wind Speed, \( V_s \) ................................ 553
17.9.6 Dynamic Pressure of the Wind ......................... 561
17.9.7 Pressure Coefficients and Force Coefficients ........ 563
17.9.8 Force Coefficients for Unclad Structures ............ 577

### 17.10 EFFECTS OF EARTHQUAKES

17.10.1 SCOPE AND FIELD OF APPLICATION .................. 582

### 17.10.3 DESIGN CRITERIA

17.10.3.1 Reliability Differentiation ....................... 583
17.10.3.2 Ductility Levels .................................... 584
17.10.4 METHODS OF ASSESSMENT ............................ 584
17.10.4.1 Basic data ........................................... 584
17.10.4.1.1 Material Characteristics ....................... 584
17.10.4.1.1 (1) Concrete ........................................................................................................684
17.10.4.1.1(2) Steel ........................................................................................................684
17.10.4.1.2 Material Safety Factor ..................................................................................684
17.10.4.1.4 Design Load Combination .......................................................................685
17.10.4.2 Structural analysis ..........................................................................................685
17.10.4.2.1 Building Configuration ...............................................................................685
17.10.4.2.2 Application of Seismic Action ..................................................................686
17.10.4.2.3 Analytical Model .......................................................................................686
17.10.5.1 Seismic Zones ...............................................................................................688
17.10.5.2 Characteristics of Seismic Actions .................................................................689
17.10.5.3 Design Seismic Action ..................................................................................689
17.10.5.3.1 Normalized Elastic Response Spectrum ...................................................689
17.10.5.3.2 Site Effects ................................................................................................689
17.10.5.3.3 Site - Dependant Normalized Elastic Response Spectrum ..........................690
17.10.5.3.4 Design Response Spectrum ......................................................................690
17.10.6 DESIGN ACTIONS ..........................................................................................691
17.10.6.1 General ..........................................................................................................691
17.10.6.2 Ductility Level I: DL I ..................................................................................691
17.10.6.3 Ductility Level II: DL II ................................................................................691
17.10.6.4 Ductility Level III: DL III .............................................................................693
17.10.7.2 Beam - Column Joints (DL III only) ...............................................................698
17.10.7.3 Structural Walls ............................................................................................600
17.10.7.4 Verifications ..................................................................................................601
17.10.8 DETAILING, EXECUTION, USE ......................................................................602
17.10.8.1 General ..........................................................................................................602
17.10.8.2 Elements Subject to Bending (N_d ≤ 0.1 \cdot A_k \cdot f_{cd}) ....................................602
17.10.8.2.1 Geometrical Constraints .........................................................................602
17.10.8.2.2 Longitudinal Reinforcement ....................................................................603
17.10.8.2.3 Minimum Transverse Reinforcement ........................................................603
17.10.8.3 Elements Subject to Bending and Axial Force (N_d > 0.1 \cdot A_k \cdot f_{cd}) ..........604
17.10.8.3.1 General .......................................................................................................604
17.10.8.3.3 Longitudinal Reinforcement .....................................................................605
17.10.8.3.4 Transverse Reinforcement .......................................................................605
17.10.8.4 Beam - Column Joints ..................................................................................609
17.10.8.4.1 Confinement .............................................................................................609
17.10.8.5 Structural Walls .............................................................................................609
17.10.8.5.1 Geometrical Constraints .........................................................................609
17.10.8.5.3 Transverse Reinforcement .......................................................................610
17.10.8.6 Anchorages and Splicing of Reinforcement ..................................................612
17.10.8.6.1 General .......................................................................................................612
17.10.8.6.2 Flexural Members: Anchorage of Longitudinal Reinforcement ..............612
17.10.8.6.3 Columns: Anchorage of Longitudinal Reinforcement ..............................613
17.10.8.6.4 Splices of Longitudinal Reinforcement ......................................................613
17.10.8.6.5 Anchorage and Splicing of Transverse Reinforcement ...............................613
APENDIX A ...............................................................................................................614
SCHEDULE OF UNIT WEIGHT OF BUILDING MATERIALS ..................................614
PART 18: SOILS AND FOUNDATIONS ...........................................................................622
18.1 GENERAL .............................................................................................................622
18.1.1 Scope .................................................................................................................622
18.2 DESIGN BASIS ...................................................................................................622
18.2.1 General .............................................................................................................622
18.3 GEOTECHNICAL INVESTIGATIONS ...................................................................622
18.3.1 General .............................................................................................................622
18.3.2 Investigations required ......................................................................................622
18.3.3 Method of investigation .....................................................................................622
18.3.3.1 Scope of investigation .....................................................................................622
18.3.4 Qualitied representative .....................................................................................622
18.3.5 Investigated conditions ......................................................................................622
18.3.5.1 Classification ................................................................................................622
18.3.5.2 Questionable soil ..........................................................................................623
18.3.5.3 Expansive soil ................................................................. 623
18.3.5.4 Ground-water table, .............................................................. 623
18.3.5.6 Rock strata ................................................................. 623
18.3.5.7 Excavation near foundations ........................................ 623
18.3.5.8 Compacted fill material .................................................. 624
18.3.5.9 Selected fill material (SFM) ............................................... 624
18.3.5.10 Alternate setback and clearance ..................................... 624
18.3.5.11 Seismic Design Categories C through F ......................... 624
18.3.5.12 Seismic Design Categories ........................................... 624
18.3.6 Reporting ........................................................................ 625
18.4 EXCAVATION, GRADING AND FILL .......................................... 626
18.4.1 Excavation near foundations ............................................. 626
18.4.2 Underpinning ................................................................... 626
18.4.2.1 Underpinning sequencing ................................................ 626
18.4.3 Placement of backfill .......................................................... 626
18.4.4 Site grading ........................................................................ 626
18.4.5 Grading and fill in flood hazard areas ................................. 626
18.4.6 Compacted fill material ....................................................... 627
18.4.7 Selected fill material (SFM) .................................................. 627
18.5 DAMPROOFING AND WATERPROOFING ............................. 627
18.5.1 General ............................................................................. 627
18.5.1.1 Storey above grade plane ................................................ 627
18.5.1.2 Under-floor space ............................................................ 627
18.5.1.3 Flood hazard areas .......................................................... 627
18.5.1.4 Ground-water control ....................................................... 628
18.5.2 Damproofing ................................................................. 628
18.5.2.1 Floors ............................................................................. 628
18.5.2.2 Walls ............................................................................ 628
18.5.2.2.1 Surface preparation of walls ......................................... 628
18.5.2.3 Waterproofing ................................................................. 628
18.5.2.4-Floors ................................................................. 628
18.5.3 Waterproofing ................................................................. 628
18.5.3.1 Floors ............................................................................. 628
18.5.3.2 Walls ............................................................................ 629
18.5.3.2.1 Surface preparation of walls ......................................... 629
18.5.3.3 Joints and penetrations ..................................................... 629
18.5.4 Subsoil drainage system ...................................................... 629
18.5.4.1 Floor base course ............................................................ 629
18.5.4.2 Foundation drain ............................................................. 629
18.5.4.3 Drainage discharge .......................................................... 629
18.6 PRESUMPTIVE LOAD-BEARING VALUES OF SOILS ............. 630
18.6.1 Load combinations ............................................................ 630
18.6.2 Presumptive load-bearing values ........................................ 630
18.6.3 Lateral load resistance ......................................................... 631
18.6.3.1 Combined resistance ....................................................... 631
18.6.3.2 Lateral sliding resistance limit ......................................... 631
18.6.3.3 Increase for depth ............................................................ 631
18.6.3.4 Increase for poles ............................................................. 631
18.7 FOUNDATION WALLS, RETAINING WALLS AND EMBEDDED POSTS AND POLES 631
18.7.1 Foundation walls ............................................................... 631
18.7.1.1 Design lateral soil loads ................................................... 631
18.7.1.2 Unbalanced backfill height .............................................. 631
18.7.1.3 Rubble stone foundation walls ........................................ 631
18.7.1.4 Permanent wood foundation systems ................................ 632
18.7.1.5 Concrete and masonry foundation walls .......................... 632
18.7.1.6 Prescriptive design of concrete and masonry foundation walls ................................................................................................................. 632
18.7.1.6.1 Foundation wall thickness ............................................ 632
18.7.1.6.2 Concrete foundation walls ........................................... 632
18.7.1.6.2.1 Seismic requirements .............................................. 632
18.7.1.6.3 Masonry foundation walls ............................................ 632
18.7.1.6.3.1 Alternative foundation wall reinforcement ................ 638
18.7.1.6.3.2 Seismic requirements .............................................. 638
18.7.2 Retaining walls ................................................................. 638
18.7.2.1 General .................................................................639
18.7.2.2 Design lateral soil loads ..........................................639
18.7.2.3 Safety factor ..........................................................639
18.7.3 Embedded posts and poles ...........................................639
18.7.3.1 Limitations .........................................................639
18.7.3.2 Design criteria ......................................................639
18.7.3.2.1 Nonconstrained ...............................................639
18.7.3.2.2 Constrained ......................................................640
18.7.3.2.3 Vertical load ......................................................640
18.7.3.3 Backfill ...............................................................640
18.8 FOUNDATIONS ...............................................................640
18.8.1 General .................................................................640
18.8.2 Design for capacity and settlement ...................................640
18.8.3 Design loads ..............................................................640
18.8.3.1 Seismic overturning ................................................640
18.8.3.2 Surcharge .............................................................640
18.8.4 Vibratory loads ...........................................................641
18.8.5 Shifting or moving soils ...............................................641
18.8.6.1 Foundations ..........................................................641
18.8.6.2 Slab-on-ground foundations ......................................641
18.8.6.3 Removal of expansive soil ........................................642
18.8.6.4 Stabilization ..........................................................642
18.8.7 Foundations on or adjacent to slopes ..............................642
18.8.7.1 Building clearance from ascending slopes .......................642
18.8.7.2 Foundation setback from descending slope surface ..........642
18.8.7.3 Pools .................................................................642
18.8.7.4 Foundation elevation ...............................................642
18.8.7.5 Alternate setback and clearance ...................................643
18.8.8 Concrete foundations ..................................................643
18.8.8.1 Concrete or grout strength and mix proportioning ...............643
18.8.8.2 Concrete cover ........................................................644
18.8.8.3 Placement of concrete ..............................................644
18.8.8.4 Protection of concrete ..............................................644
18.8.8.5 Forming of concrete ...............................................644
18.8.8.6 Seismic requirements ..............................................644
18.9 SHALLOW FOUNDATIONS ..................................................645
18.9.1 General .................................................................645
18.9.2 Supporting soils ........................................................645
18.9.3 Stepped footings ........................................................645
18.9.4 Depth and width of footings .........................................645
18.9.5 Frost protection ........................................................645
18.9.6 Location of footings ....................................................645
18.9.7 Prescriptive footings for light-frame construction ...............645
18.9.8 Plain concrete footings ...............................................646
18.9.9 Masonry-unit footings ..................................................646
18.9.9.1 Dimensions ..........................................................646
18.9.9.2 Offsets ...............................................................646
18.9.10 Pier and curtain wall foundations ....................................646
18.9.11 Steel grillage footings .................................................647
18.9.12 Timber footings ........................................................647
18.9.13 Footing seismic ties ...................................................647
18.10 DEEP FOUNDATIONS ......................................................647
18.10.1 General .................................................................647
18.10.1.1 Geotechnical investigation .......................................647
18.10.1.2 Use of existing deep foundation elements .......................647
18.10.1.3 Deep foundation elements classified as columns ...............647
18.10.1.4 Special types of deep foundations ...............................648
18.10.2 Analysis .................................................................648
18.10.2.1 Lateral support ......................................................648
18.10.2.2 Stability .............................................................648
18.10.2.3 Settlement ............................................................648

lvi
18.10.3.8.3.3 Seismic reinforcement in Seismic Design Categories D through F.
18.10.3.8.3.2 Seismic reinforcement in Seismic Design Categories D through F.
18.10.3.8.3.1 Minimum reinforcement.
18.10.3.8.2 Precast nonprestressed piles.
18.10.3.6 Splices.
18.10.3.5.3.5 Helical piles.
18.10.3.5.3.3 Structural steel sheet piling.
18.10.3.5.3.1 Structural steel H-piles.
18.10.3.5.2.2 Uncased.
18.10.3.5.2 Cast-in-place or grouted-in-place.
18.10.3.5.2.1 Cased.
18.10.3.5.2.2 Uncased.
18.10.3.5.2.3 Micropiles.
18.10.3.5.3.1 Structural steel H-piles.
18.10.3.5.3.3 Structural steel sheet piling.
18.10.3.5.3.4 Steel pipes and tubes.
18.10.3.5.3.5 Helical piles.
18.10.3.6 Splices.
18.10.3.6.1 Seismic Design Categories C through F.
18.10.3.7 Top of element detailing at cutoffs.
18.10.3.8 Precast concrete piles.
18.10.3.8.1 Reinforcement.
18.10.3.8.2 Precast nonprestressed piles.
18.10.3.8.2.1 Minimum reinforcement.
18.10.3.8.2.2 Seismic reinforcement in Seismic Design Categories C through F.
18.10.3.8.2.3 Additional seismic reinforcement in Seismic Design Categories D through F.
18.10.3.8.3 Precast prestressed piles.
18.10.3.8.3.1 Effective prestress.
18.10.3.8.3.2 Seismic reinforcement in Seismic Design Category C.
18.10.3.8.3.3 Seismic reinforcement in Seismic Design Categories D through F.
19.3.5.3 Label information.
19.3.5.1 Testing.

19.3.1.3 Personnel.
19.3.1.2 Equipment.
19.3.1.1 Independence.

19.2.1 General.

PART 19: SPECIAL INSPECTIONS AND TESTS

19.1 GENERAL
19.1.1 Scope.
19.1.2 NEW MATERIALS

19.3 APPROVALS
19.3.1 Approved agency.
19.3.1.1 Independence.
19.3.1.2 Equipment.
19.3.1.3 Personnel.
19.3.2 Written approval.
19.3.3 Record of approval.
19.3.4 Performance.
19.3.4.1 Research and investigation.
19.3.4.2 Research reports.
19.3.5 Labelling.
19.3.5.1 Testing.
19.3.5.2 Inspection and identification.
19.3.5.3 Label information.
19.3.5.4 Method of labelling.
19.3.6 Evaluation and follow-up inspection services.
19.3.6.1 Follow-up inspection.

19.2 NEW MATERIALS
19.2.1 General.

PART 18: SPECIAL INSPECTIONS AND TESTS

18.10.3.8.3.4 Axial load limit in Seismic Design Categories C through F
18.10.3.9 Cast-in-place deep foundations
18.10.3.9.1 Design cracking moment
18.10.3.9.2 Required reinforcement
18.10.3.9.3 Placement of reinforcement
18.10.3.9.4 Seismic reinforcement
18.10.3.9.4.1 Seismic reinforcement in Seismic Design Category C
18.10.3.9.4.2.1 Site Classes A through D
18.10.3.9.4.2.2 Site Classes E and F
18.10.3.9.5 Belled drilled shafts
18.10.3.9.6 Socketed drilled shafts
18.10.3.10 Micropiles
18.10.3.11 Pile caps
18.10.3.11.1 Seismic Design Categories C through F
18.10.3.11.2 Seismic Design Categories D through F
18.10.3.12 Grade beams
18.10.3.13 Seismic ties
18.10.4 Installation
18.10.4.1 Structural integrity
18.10.4.1.1 Compressive strength of precast concrete piles
18.10.4.1.2 Casing
18.10.4.1.3 Driving near uncased concrete
18.10.4.1.4 Driving near cased concrete
18.10.4.1.5 Defective timber piles
18.10.4.2 Identification
18.10.4.3 Location plan
18.10.4.4 Preexcavation
18.10.4.5 Vibratory driving
18.10.4.6 Heaved elements
18.10.4.7 Enlarged base cast-in-place elements
18.10.4.8 Hollow-stem augered, cast-in-place elements
18.10.4.9 Socketed drilled shafts
18.10.4.10 Micropiles
18.10.4.11 Helical piles
18.10.4.12 Special inspection

PART 19: SPECIAL INSPECTIONS AND TESTS

19.1 GENERAL
19.1.1 Scope
19.1.2 NEW MATERIALS

19.3 APPROVALS
19.3.1 Approved agency
19.3.1.1 Independence
19.3.1.2 Equipment
19.3.1.3 Personnel
19.3.2 Written approval
19.3.3 Record of approval
19.3.4 Performance
19.3.4.1 Research and investigation
19.3.4.2 Research reports
19.3.5 Labelling
19.3.5.1 Testing
19.3.5.2 Inspection and identification
19.3.5.3 Label information
19.3.5.4 Method of labelling
19.3.6 Evaluation and follow-up inspection services
19.3.6.1 Follow-up inspection

lix
19.3.6.2 Test and inspection records .................................................. 670
19.4 SPECIAL INSPECTIONS AND TESTS, CONTRACTOR RESPONSIBILITY AND ........................................... 670
STRUCTURAL OBSERVATION ........................................................................................................................................................................... 670
19.4.1 General .......................................................................................... 670
19.4.2 Special inspections and tests .......................................................... 670
19.4.2.1 Special inspector qualifications .................................................. 670
19.4.2.2 Access for special inspection ................................................... 670
19.4.2.3 Statement of special inspections .............................................. 670
19.4.2.4 Report requirement .................................................................. 671
19.4.2.5 Special inspection of fabricated items ...................................... 671
19.4.2.5.1 Fabricator approval ............................................................ 671
19.4.3 Statement of special inspections .................................................. 671
19.4.3.1 Content of statement of special inspections ............................... 671
19.4.3.2 Seismic requirements in the statement of special inspections .......... 672
19.4.3.3 Wind requirements in the statement of special inspections .......... 672
19.4.4 Contractor responsibility ............................................................... 672
19.4.5 Submissions to the Head of the works department .......................... 672
19.4.6 Structural observations .................................................................. 672
19.4.6.1 Structural observations for structures ....................................... 673
19.4.6.2 Structural observations for seismic resistance ............................ 673
19.4.6.3 Structural observations for wind resistance ............................... 673
19.5 REQUIRED SPECIAL INSPECTIONS AND TESTS .......................................................... 673
19.5.1 General .......................................................................................... 673
19.5.1.1 Special cases ......................................................................... 673
19.5.2 Steel construction .......................................................................... 673
19.5.2.1 Structural steel ....................................................................... 674
19.5.2.2 Cold-formed steel deck ............................................................ 674
19.5.2.3 Open-web steel joists and joist girders ...................................... 674
19.5.2.4 Cold-formed steel trusses spanning 18 metres or greater .......... 675
19.5.3 Concrete construction ................................................................. 675
19.5.3.1 Welding of reinforcing bars ..................................................... 676
19.5.3.2 Material tests .......................................................................... 676
19.5.4 Masonry construction ................................................................. 677
19.5.4.1 Empirically designed masonry, glass unit masonry and masonry veneer in Risk ............................................................. 677
19.5.5.2 Metal-plate-connected wood trusses ........................................ 677
19.5.6 Soils .............................................................................................. 677
19.5.7 Driven deep foundations ............................................................... 678
19.5.8 Cast-in-place deep foundations ..................................................... 679
19.5.9 Helical pile foundations ................................................................. 679
19.5.10 Fabricated items ......................................................................... 679
19.5.11 Special inspections for seismic resistance ..................................... 679
19.5.11.1 Structural steel ....................................................................... 680
19.5.11.1.1 Seismic force-resisting systems ........................................ 680
19.5.11.1.2 Structural steel elements .................................................. 680
19.5.12 Structural wood .......................................................................... 680
19.5.12.2 Structural wood ....................................................................... 680
19.5.12.3 Cold-formed steel light-frame construction ............................ 681
19.5.12.4 Designated seismic systems ................................................... 681
19.5.12.5 Architectural components ...................................................... 681
19.5.12.5.1 Access floors .................................................................... 681
19.5.12.6 Plumbing, mechanical and electrical components .................. 681
19.5.12.7.7 Storage racks .................................................................... 682
19.5.12.8 Seismic isolation systems ....................................................... 682
19.5.12.9 Cold-formed steel special bolted moment frames .................... 682
19.5.12 Testing for seismic resistance ...................................................... 682
19.5.12.1 Structural steel ....................................................................... 682
19.5.12.1.1 Seismic force-resisting systems ........................................ 682
19.5.12.1.2 Structural steel elements .................................................. 683
19.5.12.2 Nonstructural components ...................................................... 683
19.5.12.3 Designated seismic systems ................................................... 683
19.5.12.4 Seismic isolation systems ....................................................... 683
19.5.13 Sprayed fire-resistant materials ................................................... 683
20.3.2 Aggregates ........................................................................................................... 694
20.4 CONCRETE QUALITY .............................................................................................. 694
20.4.1 General .................................................................................................................. 694
20.4.2 Strength concrete .................................................................................................. 694
20.4.3 Trial mixes .............................................................................................................. 695
20.4.4 Nominal prescribed mix for non-structural concrete .............................................. 696
20.4.5 Consistency and workability ................................................................................. 696
20.4.6 Bleeding ................................................................................................................ 697
20.4.7 Pumped concrete .................................................................................................... 697
20.5 PLANT FOR CONCRETING OPERATIONS ................................................................. 697
20.6 MEASURING THE MATERIALS ................................................................................ 698
20.6.1 General .................................................................................................................. 698
20.6.2 Cement ................................................................................................................... 698
20.6.3 Water ...................................................................................................................... 698
20.6.4 Aggregate .............................................................................................................. 698
20.7 MIXING CONCRETE ................................................................................................. 698
20.7.1 General .................................................................................................................. 698
20.7.2 Charging the mixer ............................................................................................... 699
20.7.3 Mixing and discharging ......................................................................................... 699
20.7.4 Maintaining and cleaning the mixer ....................................................................... 699
20.7.5 Standby mixer ....................................................................................................... 699
20.7.6 Ready mixed concrete ......................................................................................... 700
20.7.7 Hand Mixed Concrete ......................................................................................... 700
20.8 TRANSPORT OF CONCRETE ................................................................................ 700
20.9 PLACING OF CONCRETE ...................................................................................... 700
20.9.1 Consent for placing .............................................................................................. 700
20.9.2 Time for placing .................................................................................................... 700
20.9.3 Placing procedures .............................................................................................. 701
20.9.4 Placing under water ............................................................................................. 702
20.9.5 Intermittent interruptions to placing ..................................................................... 702
20.9.6 Dimensions of pours ........................................................................................... 702
20.10 COMPACTION OF CONCRETE ............................................................................. 703
20.11 CURING AND PROTECTION OF CONCRETE ....................................................... 703
20.11.1 General ................................................................................................................ 703
20.11.2 Loss of moisture ................................................................................................. 703
20.11.3 Limitation of temperature differentials ................................................................. 704
20.12 PROTECTION OF FRESH CONCRETE ................................................................. 704
20.13 CONCRETING IN HOT WEATHER ......................................................................... 705
20.14 FINISHES ON UNFORMED SURFACES .............................................................. 705
20.14.1 UF 1 finish ........................................................................................................... 705
20.14.2 UF 2 finish ........................................................................................................... 705
20.14.3 UF 3 finish ........................................................................................................... 705
20.15 MORTAR .................................................................................................................. 706
20.16 CONCRETE FOR SECONDARY PURPOSES ........................................................ 706
20.17 RECORDS OF CONCRETE PLACING ................................................................. 707
20.18 CONSTRUCTION JOINTS ....................................................................................... 707
20.18.1 General ................................................................................................................ 707
20.18.2 Preparation of surfaces ....................................................................................... 707
20.19 EXPANSION AND CONTRACTION JOINTS ....................................................... 708
20.20 PRECAST CONCRETE ............................................................................................ 708
20.20.1 General ................................................................................................................ 708
20.20.2 Casting of Units ................................................................................................... 708
20.20.3 Curing of Precast Units ..................................................................................... 709
20.20.4 Surface Finish of Unformed Surfaces of Precast Units ........................................ 709
20.20.5 Handling and Storage of Precast Units ............................................................... 709
20.21 Testing Precast Units ............................................................................................ 709
PART 21: ALUMINIUM ................................................................................................. 709
21.1 GENERAL .................................................................................................................. 710
21.1 Scope ......................................................................................................................... 710
21.2 MATERIALS .............................................................................................................. 710
21.2.1 General ................................................................................................................ 710
PART 22: MASONRY

22.1 GENERAL

22.1.1 Scope

22.1.2 Design methods

22.1.2.1 Masonry veneer

22.1.3 Special inspection

22.2 NOTATIONS

22.2.1 General

22.3 MASONRY CONSTRUCTION MATERIALS

22.3.1 Masonry units

22.3.1.1 Second-hand units

22.3.2 Mortar

22.3.2.1 Masonry mortar

22.3.2.2 Surface-bonding mortar

22.3.2.3 Mortars for ceramic wall and floor tile

22.3.2.3.1 Dry-set Portland cement mortars

22.3.2.3.2 Latex-modified Portland cement mortar

22.3.2.3.3 Epoxy mortar

22.3.2.3.4 Furan mortar and grout

22.3.2.3.5 Modified epoxy-emulsion mortar and grout

22.3.2.3.6 Organic adhesives

22.3.2.3.7 Portland cement grouts

22.3.2.4 Mortar for adhered masonry veneer

22.3.3 Grout

22.3.4 Metal reinforcement and accessories

22.4 CONSTRUCTION

22.4.1 Masonry construction

22.4.1.1 Support on wood

22.4.1.2 Molded cornices

22.5 QUALITY ASSURANCE

22.5.1 General

22.6 SEISMIC DESIGN

22.6.1 Seismic design requirements for masonry

22.7 ALLOWABLE STRESS DESIGN

22.7.1 General

22.7.2 TMS 402, Clause 6.1.6.1.1, lap splices

22.7.2.1 Lap splices

22.7.2.2 TMS 402, Clause 6.1.6.1, splices of reinforcement

22.8 STRENGTH DESIGN OF MASONRY

22.8.1 General

22.8.2 TMS 402, Clause 6.1.5.1.1, development

22.8.3 TMS 402, Clause 6.1.6.1.1, splices

22.9 EMPIRICAL DESIGN OF ADOBE MASONRY

22.9.1 General

22.9.1.1 Limitations

22.9.2.1 Unstabilized adobe

22.9.2.1.1 Compressive strength

22.9.2.1.2 Modulus of rupture

22.9.2.1.2.1 Support conditions

22.9.2.1.2.2 Loading conditions

22.9.2.1.2.3 Testing procedure

22.9.2.1.2.4 Modulus of rupture determination

22.9.2.1.3 Moisture content requirements

22.9.2.1.4 Shrinkage cracks

22.9.2.2 Stabilized adobe

22.9.2.2.1 Soil requirements

22.9.2.2.2 Absorption requirements

22.9.2.3 Allowable stress

22.9.2.3.1 Bolts

22.9.2.4 Detailed requirements

22.9.2.4.1 Number of stories
22.9.2.4.2 Mortar ................................................................. 716
22.9.2.4.2.1 General ................................................................. 716
22.9.2.4.2.2 Mortar joints ......................................................... 716
22.9.2.4.3 Parapet walls ......................................................... 716
22.9.2.4.4 Wall thickness ......................................................... 716
22.9.2.4.5 Foundations .......................................................... 716
22.9.2.4.5.1 Foundation support ............................................... 716
22.9.2.4.5.2 Lower course requirements ................................... 716
22.9.2.4.6 Isolated piers or columns ....................................... 716
22.9.2.4.7 Tie beams ............................................................ 717
22.9.2.4.7.1 Concrete tie beams ............................................... 717
22.9.2.4.7.2 Wood tie beams .................................................. 717
22.9.2.4.8 Exterior finish ....................................................... 717
22.9.2.4.9 Lintels ................................................................. 717
22.10 GLASS UNIT MASONRY ............................................... 717
22.10.1 General ................................................................. 717
22.10.1.1 Limitations ............................................................ 717
22.11 MASONRY FIREPLACES ............................................... 717
22.11.1 General ................................................................. 717
22.11.2 Fireplace drawings ................................................... 718
22.11.3 Footings and foundations ........................................... 718
22.11.3.1 Ash dump cleanout ................................................ 718
22.11.4 Seismic reinforcement ............................................... 718
22.11.4.1 Vertical reinforcing ................................................. 718
22.11.4.2 Horizontal reinforcing ............................................ 718
22.11.5 Seismic anchorage .................................................... 718
22.11.6 Firebox walls .......................................................... 718
22.11.6.1 Steel fireplace units ................................................. 719
22.11.7 Firebox dimensions ................................................... 719
22.11.8 Lintel and throat ...................................................... 719
22.11.8.1 Damper ............................................................... 719
22.11.9 Smoke chamber walls ............................................... 719
22.11.9.1 Smoke chamber dimensions ...................................... 719
22.11.10 Hearth and hearth extension .................................... 720
22.11.10.1 Hearth thickness .................................................. 720
22.11.10.2 Hearth extension thickness ..................................... 720
22.11.11 Hearth extension dimensions .................................... 720
22.11.12 Fireplace clearance ................................................ 720
22.11.13 Fireplace fireblocking ............................................. 721
22.11.14 Exterior air ............................................................ 721
22.11.14.1 Factory-built fireplaces ......................................... 721
22.11.14.2 Masonry fireplaces ............................................... 721
22.11.14.3 Exterior air intake ................................................ 721
21.11.14.4 Clearance .......................................................... 721
22.11.14.5 Passageway ......................................................... 721
22.11.14.6 Outlet ............................................................... 721
22.12 MASONRY HEATERS ..................................................... 722
22.12.1 Definition .............................................................. 722
22.12.2 Installation ............................................................. 722
22.12.3 Footings and foundation .......................................... 722
22.12.4 Seismic reinforcing .................................................. 722
22.12.5 Masonry heater clearance .......................................... 722
22.13 MASONRY CHIMNEYS ................................................... 722
22.13.1 General ................................................................. 722
22.13.2 Footings and foundations .......................................... 722
22.13.3 Seismic reinforcing .................................................. 723
22.13.3.1 Vertical reinforcing ................................................. 723
22.13.3.2 Horizontal reinforcing ............................................ 723
22.13.4 Seismic anchorage .................................................... 723
22.13.5 Corbeling .............................................................. 723
22.13.6 Changes in dimension ................................................. 723
24.3.1.9 Preservative
24.3.1.8.1 Floor underlayment.
24.3.1.8 Particleboard.
24.3.1.6.2 Roof insulation.
24.3.1.1.1 Certificate of inspection.
24.3.1.2 Nominal sizes.
24.3.1.1 General.
24.3.3.2 Framing over openings.
24.3.3.3 Hardwood and plywood.
24.3.3.4.1 Design.
24.3.3.4.1.1 Truss design drawings.
24.3.3.4.1.2 Permanent individual truss member restraint.
24.3.3.4.1.3 Trusses spanning 60 feet or greater.
24.3.3.4.1.4 Truss designer.
24.3.3.4.1.5 Truss design drawings.
24.3.3.4.2 Truss placement diagram.
24.3.3.4.3 Truss Submission package.
24.3.3.4.4 Anchorages.
24.3.3.4.5 alterations to trusses.
24.3.3.4.6 GS A 573/ A 573 M specifications.
24.3.3.4.7 Truss quality assurance.
24.3.3.5 Test standard for joist hangers.
24.3.3.6 Nails and staples.
24.3.3.7 Shrinkage.
24.4 GENERAL CONSTRUCTION REQUIREMENTS.
24.4.1 General.
24.4.2 Size of structural members.
24.4.3 Wall framing.
24.4.3.1 Bottom plates.
24.4.3.2 Framing over openings.
24.4.3.3 Shrinkage.
24.4.4 Floor and roof framing.
24.4.5 Framing around flues and chimneys.
24.4.6 Exterior wall sheathing.
24.4.6.1 Wood structural panel sheathing.
24.4.7 Interior paneling.
24.4.8 Floor and roof sheathing.
24.4.8.1 Structural floor sheathing.
24.4.8.2 Structural roof sheathing.
24.4.9 Timber decking.
24.4.9.1 General.
24.4.9.2 Layup patterns.
24.4.9.2.1 Simple span pattern.
24.4.9.2.2 Two-span continuous pattern.
24.4.9.2.3 Combination simple and two-span continuous pattern.
24.4.9.2.4 Cantilevered pieces intermixed pattern.
24.4.9.2.5 Controlled random pattern.
24.4.9.2.6 Controlled random pattern.
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.4.9.4</td>
<td>Fifty millimeter sawn tongue-and-groove decking.</td>
<td>752</td>
</tr>
<tr>
<td>24.4.9.4.1</td>
<td>General</td>
<td>752</td>
</tr>
<tr>
<td>24.4.9.4.2</td>
<td>Nailing</td>
<td>752</td>
</tr>
<tr>
<td>24.4.9.4.3</td>
<td>Controlled random pattern</td>
<td>752</td>
</tr>
<tr>
<td>24.4.9.5</td>
<td>Seventy-five and one hundred sawn tongue-and-groove decking.</td>
<td>753</td>
</tr>
<tr>
<td>24.4.9.5.1</td>
<td>General</td>
<td>753</td>
</tr>
<tr>
<td>24.4.9.5.2</td>
<td>Nailing</td>
<td>753</td>
</tr>
<tr>
<td>24.4.9.5.3</td>
<td>Controlled random pattern</td>
<td>753</td>
</tr>
<tr>
<td>24.4.10.1</td>
<td>Connectors and fasteners</td>
<td>753</td>
</tr>
<tr>
<td>24.4.10.2</td>
<td>Sheathing fasteners</td>
<td>758</td>
</tr>
<tr>
<td>24.4.10.3</td>
<td>Joist hangers and framing anchors</td>
<td>758</td>
</tr>
<tr>
<td>24.4.10.4</td>
<td>Other fasteners</td>
<td>758</td>
</tr>
<tr>
<td>24.4.10.5</td>
<td>Fasteners and connectors in contact with preservative-treated and fire</td>
<td>758</td>
</tr>
<tr>
<td>24.4.10.5.1</td>
<td>Fasteners and connectors for preservative-treated wood</td>
<td>758</td>
</tr>
<tr>
<td>2304.10.5.2</td>
<td>Fastenings for wood foundations</td>
<td>759</td>
</tr>
<tr>
<td>24.4.10.5.3</td>
<td>Fasteners for fire-retardant-treated wood used in exterior applications or wet</td>
<td>759</td>
</tr>
<tr>
<td>24.4.10.5.4</td>
<td>Fasteners for fire-retardant-treated wood used in interior applications</td>
<td>759</td>
</tr>
<tr>
<td>24.4.10.6</td>
<td>Load path</td>
<td>759</td>
</tr>
<tr>
<td>24.4.10.7</td>
<td>Framing requirements</td>
<td>759</td>
</tr>
<tr>
<td>24.4.11</td>
<td>Heavy timber construction</td>
<td>759</td>
</tr>
<tr>
<td>24.4.11.1</td>
<td>Details of heavy timber structural members</td>
<td>760</td>
</tr>
<tr>
<td>24.4.11.1.1</td>
<td>Columns</td>
<td>760</td>
</tr>
<tr>
<td>24.4.11.1.2</td>
<td>Floor framing</td>
<td>760</td>
</tr>
<tr>
<td>24.4.11.1.3</td>
<td>Roof framing</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.1.2.2</td>
<td>Partitions and walls</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.2.1</td>
<td>Exterior walls</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.2.2</td>
<td>Interior walls and partitions</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.3</td>
<td>Floors</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.3.1</td>
<td>Cross-laminated timber floors</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.3.2</td>
<td>Sawn or glued-laminated plank floors</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.4</td>
<td>Roof decks</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.4.1</td>
<td>Cross-laminated timber roofs</td>
<td>761</td>
</tr>
<tr>
<td>24.4.11.4.2</td>
<td>Sawn, wood structural panel, or glued-laminated plank roofs</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12</td>
<td>Protection against decay and termites</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.1</td>
<td>Locations requiring waterborne preservatives or naturally durable wood</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.1.1</td>
<td>Joists, girders and subfloor</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.1.2</td>
<td>Wood supported by exterior foundation walls</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.1.3</td>
<td>Exterior walls below grade</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.1.4</td>
<td>Sleepers and sills</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.1.5</td>
<td>Wood siding</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.2</td>
<td>Other locations</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.2.1</td>
<td>Girder ends</td>
<td>762</td>
</tr>
<tr>
<td>24.4.12.2.2</td>
<td>Posts or columns</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.2.3</td>
<td>Supporting member for permanent appurtenances</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.2.4</td>
<td>Laminated timbers</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.2.5</td>
<td>Supporting members for permeable floors and roofs</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.2.6</td>
<td>Ventilation beneath balcony or elevated walking surfaces</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.3</td>
<td>Wood in contact with the ground or fresh water</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.3.1</td>
<td>Posts or columns</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.4</td>
<td>Termite protection</td>
<td>763</td>
</tr>
<tr>
<td>24.4.12.5</td>
<td>Wood used in retaining walls and cribs</td>
<td>764</td>
</tr>
<tr>
<td>24.4.12.6</td>
<td>Attic ventilation</td>
<td>764</td>
</tr>
<tr>
<td>24.4.12.6.1</td>
<td>Under-floor ventilation (crawl space)</td>
<td>764</td>
</tr>
<tr>
<td>24.4.13</td>
<td>Long-term loading</td>
<td>764</td>
</tr>
<tr>
<td>24.5</td>
<td>GENERAL DESIGN REQUIREMENTS FOR LATERAL FORCE-RESISTING SYSTEMS</td>
<td>764</td>
</tr>
<tr>
<td>24.5.1</td>
<td>General</td>
<td>764</td>
</tr>
<tr>
<td>24.5.1.1</td>
<td>Openings in shear panels</td>
<td>764</td>
</tr>
<tr>
<td>24.5.2</td>
<td>Diaphragm deflection</td>
<td>764</td>
</tr>
<tr>
<td>24.5.3</td>
<td>Shear wall deflection</td>
<td>767</td>
</tr>
<tr>
<td>24.6</td>
<td>ALLOWABLE STRESS DESIGN</td>
<td>767</td>
</tr>
</tbody>
</table>
24.6.1 Allowable stress design. .......................................................... 767
24.6.1.4 Timber decking.......................................................... 768
24.6.2 Wood-frame diaphragms. ......................................................... 768
24.6.2.1 Gypsum board diaphragms, ceilings. ..................................... 772
2306.3 Wood-frame shear walls. ..................................................... 772
24.7 LOAD AND RESISTANCE FACTOR DESIGN ........................................ 774
24.7.1 Load and resistance factor design ............................................ 774
24.8 CONVENTIONAL LIGHT-FRAME CONSTRUCTION ........................... 774
24.8.1 General. ........................................................................... 774
24.8.1.1 Portions exceeding limitations of conventional light-frame construction. 775
24.8.1.2 Connections and fasteners. .................................................. 775
24.8.2 Limitations. ................................................................... 775
24.8.2.1 Stories .................................................................. 775
24.8.2.2 Allowable floor-to-floor height. ............................................ 775
24.8.2.3 Allowable loads. ............................................................ 775
24.8.2.4 Basic wind speed .......................................................... 775
24.8.2.5 Allowable roof span ......................................................... 776
24.8.2.6 Risk category limitation. .................................................... 776
24.8.3 Foundations and footings. ....................................................... 776
24.8.3.1 Foundation plates or sills ................................................... 776
24.8.3.1.1 Braced wall line sill plate anchorage in Seismic Design Category D. 776
24.8.3.1.2 Braced wall line sill plate anchorage in Seismic Design Category E. 776
24.8.4 Floor framing ................................................................. 776
24.8.4.1 Girders. ................................................................. 776
24.8.4.1.1 Allowable girder spans .............................................. 776
24.8.4.2 Floor joists. ............................................................. 780
24.8.4.2.1 Span .................................................................. 780
24.8.4.2.2 Bearing ............................................................. 785
24.8.4.2.3 Framing details ..................................................... 785
24.8.4.2.4 Notches and holes. .................................................. 785
24.8.4.3 Engineered wood products. .............................................. 785
24.8.4.4 Framing around openings ................................................. 785
24.8.4.4.1 Openings in floor diaphragms in Seismic Design Categories B, C, D and E. 785
24.8.4.5 Joists supporting bearing partitions. ....................................... 787
24.8.4.6 Lateral support .......................................................... 787
24.8.4.7 Structural floor sheathing ................................................... 787
24.8.4.8 Under-floor ventilation .................................................... 787
24.8.4.9 Floor framing supporting braced wall panels. ......................... 787
24.8.4.10 Anchorage of exterior means of escape components in Seismic Design 787
24.8.5 Wall construction ............................................................ 787
24.8.5.1 Stud size, height and spacing .......................................... 787
24.8.5.2 Framing details ......................................................... 788
24.8.5.3 Plates and sills .......................................................... 788
24.8.5.3.1 Bottom plate or sill .................................................. 788
24.8.5.3.2 Top plates. .......................................................... 789
24.8.5.4 Nonload-bearing walls and partitions. ................................. 789
24.8.5.5 Openings in walls and partitions. ......................................... 789
24.8.5.5.1 Openings in exterior bearing walls .................................. 789
24.8.5.5.2 Openings in interior bearing partitions. ............................ 790
24.8.5.5.3 Openings in interior nonbearing partitions. ....................... 790
24.8.5.6 Cripple walls ............................................................ 790
24.8.5.7 Bridging ................................................................. 790
24.8.5.8 Pipes in walls ............................................................ 791
24.8.5.9 Cutting and notching ..................................................... 791
24.8.5.10 Bored holes ............................................................ 791
24.8.5.11 Exterior wall sheathing .................................................. 791
24.8.6 Wall bracing ................................................................. 791
24.8.6.1 Braced wall lines ........................................................ 791
24.8.6.2 Braced wall panels ....................................................... 794
24.8.6.3 Braced wall panel methods ............................................... 794
24.8.6.4 Braced wall panel construction ......................................... 798
24.8.6.5 Alternative bracing. ................................................................. 798
24.8.6.5.1. Alternate braced wall (ABW) ............................................. 798
24.8.6.5.2 Portal frame with hold-downs (PFH) .................................... 800
24.8.6.6 Cripple wall bracing. ............................................................. 801
24.8.6.6.1 Cripple wall bracing in Seismic Design Categories A, B and C. 801
24.8.6.6.2 Cripple wall bracing in Seismic Design Categories D and E .... 801
24.8.6.7 Connections of braced wall panels. ........................................ 801
24.8.6.7.1 Bottom plate connection. .................................................. 801
24.8.6.7.2 Top plate connection ....................................................... 806
24.8.6.7.3 Sill anchorage. .................................................................. 825
24.8.6.7.4 Anchorage to all-wood foundations ..................................... 827
24.8.6.8 Braced wall line and diaphragm support. ................................... 827
24.8.6.8.1 Foundation requirements. .................................................. 827
24.8.6.8.2 Floor and roof diaphragm support in Seismic Design Categories D and E .................................................. 828
24.8.6.8.3 Stepped footings in Seismic Design Categories B, C, D and E. 828
24.8.6.9 Attachment of sheathing. ....................................................... 829
24.8.6.10 Limitations of concrete or masonry veneer. ............................. 829
24.8.6.10.2 Limitations of concrete or masonry in Seismic Design Categories D and E .................................................. 830
24.8.7 Roof and ceiling framing. ........................................................... 830
24.8.7.1 Ceiling joist spans. ................................................................. 830
24.8.7.2 Rafter spans. ........................................................................ 830
24.8.7.3 Ceiling joist and rafter framing. .............................................. 830
24.8.7.3.1 Ceiling joist and rafter connections. .................................... 831
24.8.7.4 Notches and holes. ................................................................. 831
24.8.7.5 Wind uplift. .......................................................................... 831
24.8.7.6 Framing around openings. ...................................................... 832
24.8.7.7 Purlins. .................................................................................. 832
24.8.7.8 Blocking. ............................................................................. 832
24.8.7.9 Engineered wood products. .................................................... 833
24.8.7.10 Roof sheathing. ................................................................... 833
24.8.7.11 Joints. .................................................................................. 833
24.8.7.12 Roof planking. ..................................................................... 833
24.8.7.13 Wood trusses. ...................................................................... 836
24.8.7.14 Attic ventilation. .................................................................. 836
24.8.8 Design of elements. ................................................................... 836
24.8.8.1 Elements exceeding limitations of conventional construction. 836
24.8.8.2 Structural elements or systems not described herein. .......... 836
24.9 NEW OR ALTERNATIVE MATERIALS ........................................ 836
24.9.2 Bamboo as a Building Material .................................................. 836
24.9.2.1 Preservation ......................................................................... 836
24.9.2.2 Structural Use of Bamboo ...................................................... 836
24.9.2.3 Housing and Small Buildings; .............................................. 836
24.9.2.4 Foundations ......................................................................... 837
24.9.2.5 Flooring .............................................................................. 837
24.9.2.6 Walls .................................................................................... 837
24.9.2.7 Roofing. .............................................................................. 837
24.9.3 Scaffolding ............................................................................... 838
24.9.4 Rattan ....................................................................................... 838
24.9.5 METHODS OF TEST .................................................................. 838
PART 25: GLASS AND GLAZING ......................................................... 839
25.1 GENERAL .................................................................................... 839
25.1.1 Scope. ..................................................................................... 839
25.2 GLAZING REPLACEMENT ........................................................... 839
25.3 GENERAL REQUIREMENTS FOR GLASS ..................................... 839
25.3.1 Identification. .......................................................................... 839
25.3.2 Glass supports. ......................................................................... 839
25.3.4 Interior glazed areas. ................................................................. 839
25.4 WIND, SEISMIC AND DEAD LOADS ON GLASS .......................... 839
25.4.3 Wired, patterned and sandblasted glass. ..................................... 841
25.4.3.1 Vertical wired glass. ............................................................... 841
25.4.3.2 Sloped wired glass. ............................................................... 841
25.4.3.3 Vertical patterned glass ................................................................. 841
25.4.3.4 Sloped patterned glass ................................................................. 841
25.4.3.5 Vertical sandblasted glass ......................................................... 842
25.5 SLOPED GLAZING AND SKYLIGHTS .................................................. 842
25.5.3 Screening ...................................................................................... 842
25.5.4 Framing ......................................................................................... 843
25.5.5 Unit skylights and tubular daylighting devices .............................. 843
25.6 SAFETY GLAZING ............................................................................. 845
25.6.1 Human impact loads ...................................................................... 845
25.6.2 Impact test ..................................................................................... 845
25.6.3 Identification of safety glazing ...................................................... 846
25.6.3.1 Multipane assemblies ................................................................. 846
25.6.4.2 Glazing adjacent to doors .......................................................... 847
25.6.4.4 Glazing in guards and railings .................................................. 847
25.6.4.5 Glazing and wet surfaces ........................................................... 847
25.6.4.6 Glazing adjacent to stairways and ramps ................................. 848
25.6.4.7 Glazing adjacent to the bottom stairway landing ..................... 848
25.7 GLASS IN HANDRAILS AND GUARDS ............................................. 848
25.7.1.2 Structural glass baluster panels ................................................. 848
25.7.1.3 Parking garages .......................................................................... 849
25.8 GLAZING IN ATHLETIC FACILITIES ................................................. 849
25.8.1 General ......................................................................................... 849
25.8.2 Racquetball and squash courts ..................................................... 849
25.8.2.1 Testing ....................................................................................... 849
25.8.3 Gymnasiums and basketball courts. (Structures) ......................... 849
25.9 GLASS IN WALKWAYS, ELEVATOR HOISTWAYS AND ELEVATOR CARS 849
25.9.2 Glass in elevator hoistway enclosures ........................................ 849
25.9.3 Visions panels in elevator hoistway doors ................................... 849
PART 26: GYPSUM BOARD, GYPSUM PANEL PRODUCTS AND PLASTER 850
26.1 GENERAL ......................................................................................... 850
26.1.1 Scope .......................................................................................... 850
26.1.2 Other materials .......................................................................... 850
26.2 PERFORMANCE .............................................................................. 851
26.2.1 General ......................................................................................... 851
26.3 INSPECTION .................................................................................... 851
26.3.1 Inspection ..................................................................................... 851
26.4 VERTICAL AND HORIZONTAL ASSEMBLIES ................................ 851
26.4.1 Scope .......................................................................................... 851
26.4.1.1 Wood framing ........................................................................... 851
26.4.1.2 Studless partitions .................................................................. 851
26.5 SHEAR WALL CONSTRUCTION ......................................................... 851
26.5.1 Resistance to shear (wood framing) ............................................ 851
26.6 GYPSUM BOARD AND GYPSUM PANEL PRODUCT MATERIALS 851
26.6.1 General ......................................................................................... 851
26.6.2 Standards ..................................................................................... 851
26.7 LATHING AND PLASTERING ............................................................ 852
26.7.1 General ......................................................................................... 852
26.7.2 Standards ..................................................................................... 852
26.8 GYPSUM CONSTRUCTION ................................................................. 853
26.8.1 General ......................................................................................... 853
26.8.2 Limitations ................................................................................... 853
26.8.2.1 Weather protection ................................................................. 853
26.8.3 Single-ply application ................................................................. 853
26.8.3.1 Floating angles ......................................................................... 853
26.8.4 Adhesives ....................................................................................... 853
26.8.5 Joint treatment .............................................................................. 853
26.8.6 Horizontal gypsum board or gypsum panel product diaphragm ceilings 854
26.8.6.1 Diaphragm proportions ............................................................... 855
26.8.6.2 Installation ................................................................................ 855
26.8.6.3 Blocking of perimeter edges ................................................... 855
26.8.6.4 Fasteners ................................................................................... 855
26.10.2 Weather protection ........................................ 855
26.10.3 Installation .................................................. 855
26.10.4 Corrosion resistance ......................................... 856
26.10.5 Backing ....................................................... 856
26.10.5.1 Support of lath ........................................... 856
26.10.5.2 Use of gypsum backing board .......................... 856
26.10.5.2.1 Gypsum board as a backing board ................. 856
26.10.5.2.2 Gypsum sheathing backing ......................... 856
26.10.5.3 Backing not required .................................... 856
26.10.6 Water-resistive barriers .................................... 856
26.10.7 Preparation of masonry and concrete .................. 856
26.11 INTERIOR PLASTER ........................................... 856
26.11.1 General ....................................................... 856
26.11.1.1 Installation ............................................... 857
26.11.2 Limitations .................................................. 857
26.11.3 Grounds ...................................................... 857
26.11.4 Interior masonry or concrete .............................. 857
26.11.5 Wet areas .................................................... 857
26.12 EXTERIOR PLASTER ........................................... 857
26.12.1 General ....................................................... 857
26.12.1.1 On-grade floor slab ..................................... 857
26.12.1.2 Weep screeds ............................................ 857
26.12.2 Plasticity agents ............................................ 857
26.12.3 Limitations .................................................. 858
26.12.4 Cement plaster .............................................. 858
26.12.5 Second-coat application ................................... 858
26.12.6 Curing and interval ........................................ 858
26.12.7 Application to solid backings ............................. 858
26.12.8 Alternate method of application ......................... 858
26.12.8.1 Admixtures ................................................. 858
26.12.8.2 Curing ..................................................... 858
26.12.9 Finish coats ................................................ 858
26.13 EXPOSED AGGREGATE PLASTER ......................... 858
26.13.1 General ....................................................... 858
26.13.2 Aggregate ................................................... 858
26.13.3 Bedding coat proportions .................................. 859
26.13.4 Application .................................................. 859
26.13.5 Bases ......................................................... 859
26.13.6 Preparation of masonry and concrete ................. 859
26.13.7 Curing of base coats ....................................... 859
26.14 REINFORCED GYPSUM CONCRETE ....................... 859
26.14.1 General ....................................................... 859
26.14.2 Minimum thickness ........................................ 859
PART 27: PLASTICS .................................................. 859
27.1 GENERAL ........................................................ 859
27.1.1 Scope ........................................................ 859
27.2 FINISH AND TRIM ............................................. 860
27.2.1 Exterior finish and trim .................................... 860
27.2.2 Interior finish and trim .................................... 860
27.3 FOAM PLASTIC INSULATION .................................. 860
27.3.1 General ....................................................... 860
27.3.2 Labeling and identification ................................ 860
27.3.4 Thermal barrier ............................................. 860
27.3.4.1 Thermal barrier not required ......................... 860
27.3.4.1.1 Masonry or concrete construction ................. 861
27.3.4.1.2 Cooler and freezer walls. ................................................................. 861
27.3.4.1.3 Walk-in coolers ............................................................................... 861
27.3.4.1.11 Interior trim .................................................................................. 861
27.3.4.1.12 Interior signs ................................................................................ 861
27.3.4.1.13 Type III construction .................................................................. 861
27.3.4.1.14 Floors ......................................................................................... 861
27.3.5 Exterior walls of buildings of any height .............................................. 862
27.3.5.1 Fire-resistance-rated walls ............................................................... 862
27.3.5.2 Thermal barrier ................................................................................ 862
27.3.5.3 Potential heat ................................................................................... 862
27.3.5.4 Flame spread and smoke-developed indices. .............................. 862
27.3.5.5 Vertical and lateral fire propagation ................................................ 862
27.3.5.6 Label required .................................................................................. 862
27.3.5.7 Ignition ............................................................................................ 863
27.3.6 Roofing ............................................................................................... 863
27.3.7 Foam plastic in plenums as interior finish or interior trim .......... 863
27.3.8 Protection against termites ................................................................. 864
27.3.9 Special approval .................................................................................. 864
27.3.10 Wind resistance ............................................................................... 864
27.3.12 Cladding attachment over foam sheathing to cold-formed steel framing. 864
27.3.12.1 Direct attachment ........................................................................ 865
27.3.12.2 Furred cladding attachment. .......................................................... 866
27.3.13 Cladding attachment over foam sheathing to wood framing .... 867
27.3.13.1 Direct attachment ........................................................................ 867
27.3.13.2 Furred cladding attachment. .......................................................... 868
27.4 INTERIOR FINISH AND TRIM ................................................................. 869
27.4.1 General ............................................................................................... 869
27.4.1.1 Plenums .......................................................................................... 869
27.4.1.2 Interior trim ..................................................................................... 869
27.4.2.1 Density ............................................................................................ 869
27.4.2.2 Thickness ......................................................................................... 869
27.4.2.3 Area limitation ................................................................................ 869
27.4.2.4 Flame spread .................................................................................. 869
27.5 PLASTIC FINISH .................................................................................... 869
27.5.1 Interior use .......................................................................................... 869
27.5.2 Exterior use ........................................................................................ 869
27.5.3 Plastic siding ...................................................................................... 869
27.6 LIGHT-TRANSMITTING PLASTICS ......................................................... 869
27.6.1 General ............................................................................................... 869
27.6.2 Approval for use ............................................................................... 869
27.6.3 Identification ...................................................................................... 870
27.6.4 Specifications ..................................................................................... 870
27.6.5 Structural requirements ................................................................... 870
27.6.6 Fastening ............................................................................................ 870
27.6.7 Light-diffusing systems .................................................................... 870
27.6.7.1 Support .......................................................................................... 870
27.6.7.2 Installation ...................................................................................... 870
27.6.7.3 Size limitations .............................................................................. 871
27.6.7.4 Fire suppression system ................................................................. 871
27.6.7.5 Electrical luminaires .................................................................... 871
27.6.8 Partitions ............................................................................................ 871
27.6.9 Bathroom accessories ....................................................................... 871
27.6.10 Awnings, patio covers and similar structures ............................ 871
27.6.11 Greenhouses .................................................................................... 871
27.6.12 Solar collectors ............................................................................... 871
27.7 LIGHT-TRANSMITTING PLASTIC WALL PANELS ............................. 871
27.7.1 General ............................................................................................... 871
27.7.2 Installation ........................................................................................ 871
27.7.3 Height limitation .............................................................................. 872
27.7.4 Area limitation and separation .......................................................... 872
27.7.5 Automatic sprinkler system ............................................................... 872
27.7.6 Combinations of glazing and wall panels ................................................................. 873
27.8 LIGHT-TRANSMITTING PLASTIC GLAZING ............................................................... 873
27.8.1 Buildings of Type VB construction ........................................................................... 873
27.9 LIGHT-TRANSMITTING PLASTIC ROOF PANELS ....................................................... 873
27.9.1 General ....................................................................................................................... 873
27.9.2 Separation .................................................................................................................. 873
27.9.3 Location ..................................................................................................................... 874
27.9.4 Area limitations ........................................................................................................ 874
27.10 LIGHT-TRANSMITTING PLASTIC SKYLIGHT GLAZING ............................................. 874
27.10.1 Light-transmitting plastic glazing of skylight assemblies ......................................... 874
27.10.2 Mounting ................................................................................................................ 874
27.10.3 Slope ....................................................................................................................... 875
27.10.4 Maximum area of skylights ..................................................................................... 875
27.10.5 Aggregate area of skylights .................................................................................... 875
27.10.6 Separation ................................................................................................................ 875
27.10.7 Location ................................................................................................................... 875
27.10.8 Combinations of roof panels and skylights .............................................................. 875
27.11 LIGHT-TRANSMITTING PLASTIC INTERIOR SIGNS ................................................ 875
27.11.1 General ................................................................................................................... 875
27.11.2 Maximum area ....................................................................................................... 876
27.11.3 Separation ............................................................................................................... 876
27.11.4 Encasement ............................................................................................................ 876
27.12 PLASTIC COMPOSITES .............................................................................................. 876
27.12.1 General ................................................................................................................... 876
27.12.2 Labeling .................................................................................................................. 876
27.12.3 Flame spread index .............................................................................................. 876
27.12.4 Termite and decay resistance ............................................................................... 876
27.12.5 Construction requirements .................................................................................. 876
27.12.5.1 Span rating ........................................................................................................ 876
27.12.6 Plastic composite deck boards, stair treads, handrails and guards ......................... 876
27.13 FIBRE-REINFORCED POLYMER ................................................................................ 876
27.13.1 General ................................................................................................................... 876
27.13.2 Labeling and identification ..................................................................................... 876
27.13.3 Interior finishes ....................................................................................................... 877
27.13.3.1 Foam plastic cores .......................................................................................... 877
27.13.4 Light-transmitting materials .............................................................................. 877
27.13.5 Exterior use ............................................................................................................ 877
27.14 REFLECTIVE PLASTIC CORE INSULATION .............................................................. 878
27.14.1 General ................................................................................................................... 878
27.14.2 Identification ......................................................................................................... 878
27.14.3 Surface-burning characteristics ......................................................................... 878
27.14.4 Room corner test heat release ............................................................................ 878
PART 28: ELECTRICAL SYSTEMS AND ALLIED INSTALLATIONS .................................. 878
28.1 GENERAL .................................................................................................................... 878
28.1.1 Scope ...................................................................................................................... 878
28.2 DEFINITIONS AND CONVENTIONAL SYMBOLS ...................................................... 878
28.2.1 For the purpose of this Clause, the following definitions shall apply ....................... 878
28.2.2 CONVENTIONAL SYMBOLS ................................................................................ 884
28.3 GENERAL REQUIREMENTS ...................................................................................... 884
28.3.1 Conformity with Ghana Wiring Code .................................................................... 884
28.3.2 Materials ................................................................................................................ 884
28.3.3 Co-ordination with Local Supply Authority ............................................................ 884
28.3.4 Power Factor Improvement in Consumers’ Installation ............................................ 885
28.3.5 Execution of Work .................................................................................................. 885
28.4 PLANNING OF ELECTRICAL INSTALLATIONS ......................................................... 885
28.4.1 General ................................................................................................................... 885
28.4.2 All electrical apparatus shall be suitable for the services these are intended for: .... 885
28.4.3 Co-ordination .......................................................................................................... 885
28.4.2.1 Location ............................................................................................................. 886
28.4.2.2 Type of building for substations ....................................................................... 887
28.4.2.3 Layout of substation ................................................................. 887
28.4.2.4 Room/spaces required ............................................................ 887
28.4.3 Location of switch room ............................................................ 890
28.4.4 Location and requirements of distribution panels ......................... 891
28.4.5 Substation safety ...................................................................... 891
28.4.6 Overhead lines, wires and cables ................................................. 891
28.4.6.1 Height requirement ................................................................ 891
28.4.6.2 Position, insulation and protection of overhead lines ................. 892
28.4.6.3 Precautions against access and warnings of dangers .................. 892
28.4.6.4 Fitting of insulators to stay wires ............................................. 892
28.4.7 Maps of underground networks .................................................. 892
28.5 LIGHTING ............................................................................. 893
28.5.1 Principles of lighting ................................................................ 893
28.5.1.1 Aims of good lighting ............................................................ 893
28.5.1.1.1 Realization of these aims involves: ...................................... 893
28.5.1.2 Planning the brightness pattern .............................................. 893
28.5.1.3 Recommended values of illuminance ...................................... 894
28.5.1.3.1 The different locations and tasks are grouped within the following four clauses: 894
28.5.1.4 Glare ............................................................................. 894
28.5.1.5 Lighting for movement about a building .................................. 895
28.5.1.5.1 Corridors, passages and stairways ..................................... 895
28.5.1.5.2 Entrances .................................................................... 908
28.5.2 Daylight ............................................................................ 908
28.5.2.4 Components of Daylight Factor ............................................ 908
28.5.2.5 Sky Component (SC) ............................................................ 909
28.5.2.5.2 Corrections for window bars ........................................... 909
28.5.2.5.3 Correction for glazing ..................................................... 909
28.5.2.5.4 Correction for external obstructions ................................. 909
28.5.2.6 External Reflected Component (ERC) .................................... 909
28.5.2.6.1 For method of calculating ERC, reference may be made to accepted standard .... 909
28.5.2.7 Internal Reflected Component (IRC) ...................................... 909
28.5.2.8 General principles of openings to afford good lighting ............ 910
28.5.2.9 Availability of daylight in multi-storeyed block ........................ 910
28.5.3 Artificial lighting ................................................................... 911
28.5.3.2 Artificial lighting design for interiors ...................................... 911
28.5.3.2.2 Selection of the light sources and luminaires ..................... 912
28.5.3.2.3 Determination of the luminous flux .................................. 912
28.5.3.2.4 Arrangement of the luminaires ........................................ 912
28.5.3.3 Artificial lighting to supplement daylighting ......................... 913
28.5.4 Energy conservation in lighting ................................................. 914
28.5.4.3.3 Method of use ............................................................... 915
28.5.4.6 Artificial lighting ................................................................. 916
28.5.4.6.1 Efficient artificial light sources and luminaires .................. 916
28.5.4.7 Cleaning schedule for window panes and luminaires .......... 918
28.5.4.8 Photocontrols for artificial lights .......................................... 918
28.5.4.9 Solar Photovoltaic Systems (SPV), ........................................ 918
28.5.4.9.1 SPV lighting system should preferably be provided with CFL for energy efficiency .... 918
28.5.4.9.3 Regular maintenance of SPV system is necessary for its satisfactory functioning .... 918
28.6 ELECTRICAL POWER AND LIGHTING SYSTEMS ...................... 918
28.6.2.1.1 Occupant sensor control function ..................................... 919
28.6.2.1.2 Occupant sensor control function in warehouses ................. 919
28.6.2.1.3 Occupant sensor control function in open plan office areas .......... 919
28.6.2.2 Time-switch controls ............................................................. 920
28.6.2.2.1 Time-switch control function .......................................... 920
28.6.2.2.2 Light-reduction controls ................................................ 920
28.6.2.3 Daylight-responsive controls ............................................... 921
28.7 DISTRIBUTION OF SUPPLY AND CABLING ............................ 924
28.7.1 General ........................................................................... 924
28.7.2 System of Supply ................................................................ 924
28.7.2.1 All electrical apparatus shall be suitable for the voltage and frequency of supply ...... 924
28.7.3 Substation equipment and accessories ....................................... 925
28.7.3.1 High voltage switchgear ........................................................................... 925
28.7.3.2 Cables ........................................................................................................ 926
28.7.3.2.4 Colour identification of cores of non-flexible cables ......................... 926
28.7.3.2.5 Colour, identification of cores of flexible cables and flexible cords. .... 926
28.7.3.3 High voltage busbar trunking/ducting ...................................................... 927
28.7.3.4 MV/LV busbar trunking/rising mains ....................................................... 927
28.7.3.5 Transformers .............................................................................................. 928
28.7.3.6 Switchgear .................................................................................................. 929
28.7.3.6.2 Location .................................................................................................. 930
28.7.3.6.3 Distribution boards ................................................................................. 930
28.7.3.6.4 Branch distribution boards ................................................................... 933
28.7.3.6.5 Location of distribution boards ............................................................... 934
28.7.3.6.6 Protection of circuits .............................................................................. 934
28.7.4 Voltage and frequency of supply .................................................................. 935
28.7.5 Rating of cables and equipments .................................................................. 935
28.7.6 Installation circuits ......................................................................................... 935
28.7.6.1 Selecting and installing cables ..................................................................... 936
28.7.6.1.1 Cable insulation types ............................................................................. 936
28.7.6.1.2 Circuit wire sizes ..................................................................................... 936
28.7.6.2 Requirements for physical protection of underground cables ................. 937
28.7.7 Lighting and levels of illumination .................................................................. 937
28.7.7.1 General ........................................................................................................ 937
28.7.7.2 Future demand ............................................................................................ 938
28.7.7.3 Principles of lighting ................................................................................... 938
28.7.7.6 Energy conservation ................................................................................... 938
28.7.9 Guidelines for electrical layout in residential buildings ............................... 938
28.7 WIRING ............................................................................................................ 940
28.8 FITTING AND ACCESSORIES .......................................................................... 940
28.8.9.1 Ceiling roses and similar attachments ......................................................... 940
28.8.9.2 Socket-outlets and plugs ............................................................................. 940
28.8.9.3 Lighting fittings .......................................................................................... 940
28.8.9.4. Fitting – wire ............................................................................................ 941
28.8.9.5 Lamp holders ............................................................................................. 941
28.8.9.6 Outdoor lamps ........................................................................................... 941
28.8.9.7 Lamps .......................................................................................................... 941
28.8.9.8 Fans, regulators and clamps ........................................................................ 941
28.8.9.8.1 Ceiling fans ............................................................................................. 941
28.8.9.8.2 Exhaust fans ............................................................................................ 942
28.8.9.10 Interchangeability ...................................................................................... 944
28.8.9.11 Equipment .................................................................................................. 944
28.8.9.12 Fannage .................................................................................................... 944
28.8.10 EARTHING .................................................................................................. 944
28.8.10.1 General ....................................................................................................... 944
28.8.10.2 Earth electrodes ......................................................................................... 945
28.8.10.4 Equipment and portions of installations which shall be earthed .......... 946
28.8.10.4.1 Equipment to be earthed ....................................................................... 946
28.8.10.4.2 Structural metal work ............................................................................ 946
28.8.10.5 Neutral earthing ......................................................................................... 946
28.8.10.6 System of earthing ..................................................................................... 948
28.8.11 INSPECTION AND TESTING OF INSTALLATION ..................................... 949
28.8.11.1 General requirements ............................................................................... 949

lxxvi
29.2.3.4.6 Air movement ................................................................. 991
29.2.3.4.6.1 Fire and smoke control ................................................ 992
29.2.3.4.6.2 Removal of particulate matter from air ............................................. 992
29.2.3.4.6.3 Removal of fumes and smells from air .................................... 996
29.2.3.4.7 Measurement ....................................................................... 996
29.2.3.5 Statutory regulation and safety considerations ........................................ 996
29.2.3.5.1 Authorities and approval of schemes ........................................ 996
29.2.3.5.2 Fire and safety considerations ..................................................... 997
29.2.3.5.2.1 Design principles ................................................................. 997
29.2.3.5.2.2 Ductwork and enclosures ....................................................... 997
29.2.3.5.2.3 Thermal and acoustic insulation ................................................ 997
29.2.3.5.2.4 Fire and smoke detection ....................................................... 997
29.2.3.5.2.5 Smoke control ................................................................. 997
29.2.3.6 Application factors ................................................................. 998
29.2.3.6.1 General ................................................................. 998
29.2.3.6.1.1 Commercial applications .......................................................... 998
29.2.3.6.1.2 Offices ............................................................................. 998
29.2.3.6.1.3 Hotel guest rooms ............................................................... 998
29.2.3.6.1.4 Restaurants, cafeteria, bars and night-clubs .................................. 999
29.2.3.6.1.5 Department stores/shops ....................................................... 999
29.2.3.6.1.6 Theatres/auditoria ............................................................... 999
29.2.3.6.1.7 Special applications ............................................................... 999
29.2.3.6.1.7.1 Hospital/operating theatres .................................................. 999
29.2.3.6.1.7.2 Computer rooms .............................................................. 1000
29.2.3.6.1.8 Residential buildings ........................................................... 1000
29.2.4 Noise and vibration control ........................................................ 1000
29.2.4.1 General ............................................................................. 1000
29.2.4.2 Types of noise in building ......................................................... 1000
29.2.4.2.1 Externally created noise .......................................................... 1000
29.2.4.2.2 Generated noise .................................................................. 1001
29.2.4.2.3 Transmitted noise ................................................................. 1001
29.2.4.2.4 Intermittent noise ................................................................. 1001
29.2.4.5 Noise control ................................................................. 1001
29.2.4.5.2 From split air-conditioner/furred in ............................................ 1001
29.2.4.5.3 Air handling units (floor mounted and ceiling suspended) ................ 1002
29.2.4.5.4 From plenum chamber ............................................................ 1002
29.2.4.5.5 From fans ........................................................................... 1002
29.2.4.5.5.1 Centrifugal fans ................................................................... 1002
29.2.4.5.5.2 Axial fans ........................................................................... 1002
29.2.4.5.5.3 To reduce fan noise, the following should be adopted: ................. 1002
29.2.4.5.6 From chillers, pumps and pipes .................................................. 1003
29.2.4.5.7 From ducting work ............................................................... 1003
29.2.4.6 Structure borne noise .............................................................. 1004
29.2.4.7 Measurement ....................................................................... 1004
29.2.5 Mechanical ventilation (for non air conditioned areas) and evaporative cooling .......................................................... 1005
29.2.5.1 Ventilation ........................................................................ 1005
29.2.5.2 Beneficial effects of ventilation ................................................... 1006
29.2.5.2.1 Fresh air supply ................................................................. 1006
29.2.5.2.2 Transfer of heat/moisture .......................................................... 1006
29.2.5.2.3 Air movement ................................................................. 1006
29.2.5.2.4 Air purity and filtration ............................................................ 1006
29.2.5.2.5 Removal of particulate matter from air ........................................... 1006
29.2.5.2.6 Fire and smoke control ............................................................ 1006
29.2.5.2.7 Removal of fumes and smells from air ........................................... 1006
29.2.5.3 Industrial ventilation ............................................................... 1007
29.2.5.4 Types of ventilation systems ...................................................... 1007
29.2.5.4.1 Mechanical extract/natural supply ............................................. 1007
29.2.5.4.2 Mechanical supply/natural extract ............................................... 1007
29.2.5.4.3 Combined mechanical supply and extract ..................................... 1007
29.2.5.5 Ventilation rate and design consideration for non-air conditioned areas .......................................................... 1007
29.2.5.5.1 General ventilation ............................................................... 1007
29.2.5.5.2 Kitchen (industrial and commercial) ventilation ................................. 1009
29.2.12.3 Commissioning, testing, adjusting and balancing ........................................... 1026
29.2.12.3.1 Basic considerations ....................................................................................... 1026
29.2.12.3.1.1 The basic considerations are: ................................................................... 1026
29.2.12.3.2 System testing, adjusting and balancing ....................................................... 1026
29.2.12.3.2.1 Refrigeration plant .................................................................................... 1026
29.2.12.3.2.2 Air system ............................................................................................... 1026
29.2.12.3.2.2.1 Air handlers performance .................................................................... 1026
29.2.12.3.2.2.2 Air distribution ..................................................................................... 1027
29.2.12.3.2.2.3 Hydronic system .................................................................................. 1027
29.2.12.4 Controls ........................................................................................................... 1027
29.2.12.5 Noise and sound control .................................................................................. 1027
29.2.12.6 Handover procedure ....................................................................................... 1027
29.3 VENTILATION ........................................................................................................... 1028
29.3.1 General ................................................................................................................ 1028
29.3.1.1 Scope ............................................................................................................... 1028
29.3.1.2 Ventilation required ........................................................................................ 1028
29.3.1.5 Intake opening protection ................................................................................ 1028
29.3.1.6 Contaminant sources ....................................................................................... 1029
29.3.2 Natural Ventilation .............................................................................................. 1029
29.3.2.1 Natural ventilation ........................................................................................... 1029
29.3.2.2 Adjoining spaces ............................................................................................. 1029
29.3.2.4 Openings below grade .................................................................................... 1029
29.3.2.3 Opening spaces ............................................................................................... 1029
29.3.2.4 Mechanical Ventilation .................................................................................. 1029
29.3.3.1 Ventilation system ........................................................................................... 1029
29.3.3.2.2 Transfer air ................................................................................................. 1030
29.3.3.3 Outdoor air and local exhaust airflow rates ....................................................... 1030
29.3.3.3.1 Other buildings intended to be occupied ...................................................... 1030
29.3.3.3.1.1 Outdoor airflow rate ................................................................................ 1030
29.3.3.3.1.2 Exhaust ventilation .................................................................................. 1030
29.3.3.3.1.3 System operation ..................................................................................... 1030
29.3.3.3.1.4 Variable air volume system control ......................................................... 1030
29.3.3.3.1.5 Balancing ................................................................................................. 1030
29.3.3.3.2.1 Outdoor air for dwelling units ................................................................. 1030
29.3.3.3.4 Enclosed Parking Garages ........................................................................... 1038
29.3.3.3.4.1 Enclosed parking garages ........................................................................ 1038
29.3.3.5 Systems Control .............................................................................................. 1038
29.3.3.5.1 General ........................................................................................................ 1038
29.3.3.6 Ventilation of Uninhabited Spaces .................................................................. 1038
29.3.3.6.1 General ....................................................................................................... 1038
29.3.3.7 Ambulatory Care Facilities and Group I-2 Occupancies .................................. 1038
29.4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL ...................... 1039
29.4.1 SCOPE ................................................................................................................ 1039
29.4.2 PLANNING AND DESIGN AGAINST OUTDOOR NOISE (ACOUSTICS) .... 1039
29.4.2.1 General ........................................................................................................... 1039
29.4.2.2 Traffic Noise Levels ........................................................................................ 1039
29.4.2.2.1 For Air Traffic .............................................................................................. 1039
29.4.2.2.2 For Rail Traffic ............................................................................................ 1039
29.4.2.2.3 For Road Traffic .......................................................................................... 1040
29.4.2.3 Outdoor Noise Regulations ............................................................................. 1040
29.4.2.4 Planning and Design ....................................................................................... 1040
29.4.2.4.1 For Air Traffic .............................................................................................. 1040
29.4.2.4.2 Rail Traffic .................................................................................................. 1041
29.4.2.4.3 Road Traffic ............................................................................................... 1041
29.4.2.5 Zoning ............................................................................................................. 1042
29.4.2.6 Green Belts and Landscaping ......................................................................... 1042
29.4.2.7 Highway Noise Barriers ................................................................................. 1042
29.4.2.8 Special Problems Requiring Expert Advice .................................................... 1043
29.4.3 PLANNING AND DESIGN AGAINST INDOOR NOISE ......................... 1043
29.4.3.1 Acceptable indoor noise levels in buildings ..................................................... 1043
29.4.3.2 Vulnerable Buildings ....................................................................................... 1043
29.4.3.5 Special problems requiring expert advice (see 29.4.2.8 and Appendix E) ....... 1043
29.4.8.2 Recommendations ................................................................. 1055
29.4.8.2.1 Site planning ........................................................................ 1055
29.4.8.2.2 Internal planning ................................................................. 1055
29.4.9 INDUSTRIAL BUILDINGS ............................................................... 1056
29.4.9.1 General ................................................................................... 1056
29.4.9.2 Sources of industrial noise ....................................................... 1056
29.4.9.2.1.1 Impact ............................................................................ 1056
29.4.9.2.1.2 Friction .......................................................................... 1056
29.4.9.2.1.3 Rotation and reciprocation ............................................... 1056
29.4.9.2.1.4 Air turbulence .................................................................. 1057
29.4.9.2.1.5 Noises with pure tone components .................................. 1057
29.4.9.3 Noise criteria .......................................................................... 1057
29.4.9.3.1 Hearing damage-risk criteria .............................................. 1057
29.4.9.3.2 Interference with Communication ....................................... 1057
29.4.9.4 Methods of reducing noise ...................................................... 1057
29.4.9.4.1 Noise control by location ..................................................... 1057
29.4.9.4.2 Noise reduction by layout .................................................... 1057
29.4.9.4.3 Noise reduction at source ..................................................... 1057
29.4.9.4.3.1 Selection of machinery ................................................... 1057
29.4.9.4.3.2 Reducing noise from potential sources ............................. 1057
29.4.9.4.3.5 Reducing transmission of mechanical vibration ............. 1058
29.4.9.4.4 Noise reduction by enclosures and barriers (Noise Control) 1060
29.4.9.4.4.1 Enclosures ...................................................................... 1060
29.4.9.4.4.2 Barriers .......................................................................... 1060
29.4.9.4.5 Acoustic absorption devices .............................................. 1061
29.4.9.4.5.1 Acoustic treatment of ceilings and side walls ................. 1061
29.4.9.4.5.2 Functional around absorbers .......................................... 1061
29.4.10 LABORATORIES AND TEST HOUSES .................................... 1061
29.4.10.1 Sources of noise ................................................................. 1061
29.4.10.1.1 Outdoor noise .................................................................... 1061
29.4.10.2 Recommendations ............................................................... 1061
29.4.10.2.1 Site planning ..................................................................... 1061
29.4.10.2.2 Internal planning ............................................................... 1061
29.4.11 MISCELLANEOUS BUILDINGS .................................................. 1062
29.4.11.1 Law courts and council chambers ....................................... 1062
29.4.11.2 Libraries, museums and art galleries ................................... 1062
29.4.11.3 Auditoria and theatres ........................................................... 1063
A-1 GENERAL ..................................................................................... 1064
A-2 ADDITION OF TWO NOISE LEVELS .............................................. 1064
A-3 SUBTRACTION OF TWO NOISE LEVELS ..................................... 1065
A-4 NON-UNIFORM COMPOSITE PARTITIONS .................................. 1065
A-5 A- WEIGTING CALCULATIONS ..................................................... 1065
B.1 GENERAL ..................................................................................... 1068
B-2 INSULATION AGAINST AIR-BORNE SOUND .............................. 1068
B-3 INSULATION AGAINST IMPACT SOUND .................................... 1069
B-4 RATING SOUND INSULATION ..................................................... 1069
E-1 GENERAL ..................................................................................... 1071
E-2 ACOUSTIC TEST ROOMS ............................................................... 1071
E-3 PERFORMING SPACES ................................................................. 1071
E-4 BROADCASTING AND RECORDING STUDIOS .......................... 1071
E-5 AIRCRAFT NOISE ......................................................................... 1072
E-6 GROUND-BORNE NOISE ............................................................... 1072
E-7 LOW-FREQUENCY NOISE ............................................................. 1072
E-8 ACTIVE NOISE CONTROL .............................................................. 1072
E-9 NOISE SURVEYS .......................................................................... 1072
F-1 GENERAL ..................................................................................... 1072
F-2 DIRECT AND INDIRECT TRANSMISSION .................................... 1072
F-3 AIR-BORNE SOUND INSULATION ............................................... 1075
F-3.1 General ....................................................................................... 1075
F-3.2 Terminology ................................................................................. 1075
F-3.3 Mass law ..................................................................................... 1075
F-3.4 The Coincidence effect .......................................................... 1076
F-3.5 Mass-spring-mass frequency ................................................... 1077
F-3.6 Impact sound control ............................................................. 1077
F-4AIR-BORNE INSULATION VALUES OF WALLS AND AIR-BORNE AND IMPACT INSULATION VALUES OF FLOORS .................................................. 1077
29.5 GAS SUPPLY ........................................................................ 1083
For Gas supply, installation and inspection shall comply with Ghana Standards ........................................ 1083
29.5.1 Scope .............................................................................. 1083
29.5.2 Definitions ...................................................................... 1083
29.5.4 Existing work ................................................................. 1083
29.5.5 Rules for turning gas on ..................................................... 1084
29.5.7 Installation of gas pipes ...................................................... 1085
29.5.7.2 Piping ........................................................................ 1085
29.5.7.4 Piping underground ...................................................... 1085
29.5.7.4.1 Protection of piping .................................................. 1085
29.5.7.4.2 Protection against corrosion ...................................... 1085
29.5.7.7 Pipe entrance to buildings ............................................. 1086
29.5.7.7.1 Piping in floors ......................................................... 1086
29.5.7.11 Prohibited devices ....................................................... 1086
29.5.9 Leakage check .................................................................. 1087
29.5.9.2 Checking for gas leakage ............................................. 1087
29.5.9.3 Use of lights ................................................................. 1087
29.5.9.4 Checking for leakage with meter ................................... 1087
29.5.9.5 Checking of leakage without using a meter ................... 1087
29.5.10 LPG cylinder installation .................................................. 1087
29.5.10.1 General recommendations .......................................... 1087
29.5.10.3 Cylinder location ......................................................... 1088
29.5.10.3.2.1 Stationary installations ....................................... 1088
29.5.10.3.2.2 Portable installations ......................................... 1089
29.5.10.3.3 Cylinder manifolds ................................................... 1089
29.5.10.3.4 Pressure Regulators ................................................ 1089
29.5.10.3.5 Instructions to consumers ......................................... 1090
29.5.10.4 LPG Bulk storage installations ...................................... 1090
29.5.10.4.1 Location and Spacing of Storage Tanks .................. 1090
29.5.10.4.2.1 Bunding ............................................................. 1090
29.5.10.4.3 Protection ............................................................... 1091
29.5.10.4.4 Grass and Weed Removal ....................................... 1091
29.5.10.4.5 Warning signs ......................................................... 1091
29.5.10.4.6 Fire protection ......................................................... 1091
29.5.10.4.6.1 Water supply ...................................................... 1091
29.5.10.4.6.2 Fire extinguishers ............................................... 1091
29.6 EXHAUST SYSTEMS ............................................................. 1092
29.6.1 General .......................................................................... 1092
29.6.1.2 Independent system required ....................................... 1093
29.6.1.3 Exhaust discharge ....................................................... 1093
29.6.1.3.2 Exhaust opening protection ...................................... 1094
29.6.1.4 Pressure equalization .................................................... 1094
29.6.2 Required Systems .............................................................. 1094
29.6.2.1 General ....................................................................... 1094
29.6.2.1.3 Equipment, appliance and service rooms .................. 1094
29.6.2.2 Aircraft fueling and defueling ........................................ 1094
29.6.2.3 Battery-charging areas for powered industrial trucks and equipment ........................................ 1094
29.6.2.4 Stationary storage battery systems .................................. 1094
29.6.2.4.1 Flammability limit in rooms ..................................... 1095
29.6.2.4.3 Supervision ............................................................ 1095
29.6.2.5 Ventilation of battery systems in cabinets ....................... 1095
29.6.2.7 Limited spraying spaces ............................................... 1095

lxxxiv
29.6.2.7.3.3 Air velocity .......................................................... 1096
29.6.2.7.3.3.1 Open face or open front spray booth ............................. 1096
29.6.2.7.3.6 Fan motors and belts .............................................. 1097
29.6.2.7.4 Dipping operations .................................................. 1097
29.6.2.7.6 Powder coating ....................................................... 1097
29.6.2.7.7 Floor resurfacing operations ....................................... 1097
29.6.2.8.1 Storage in excess of the maximum allowable quantities ........ 1097
29.6.2.8.1.1 System requirements ............................................. 1097
29.6.2.8.2 Gas rooms, exhausted enclosures and gas cabinets ............... 1098
29.6.2.8.4.1 Indoor dispensing and use—pointsource ....................... 1098
29.6.2.8.5 Closed systems ...................................................... 1098
29.6.2.9.1 Compressed gases—medical gas systems .......................... 1098
29.6.2.9.2 Corrosives ............................................................ 1099
29.6.2.9.3 Cryogenics ........................................................... 1099
29.6.2.9.3.1 Vaults ............................................................... 1099
29.6.2.9.5.4 Use, dispensing and mixing .................................... 1099
29.6.2.9.5.1 General ............................................................. 1100
29.6.2.9.6.2 Open and closed systems ...................................... 1100
29.6.2.9.8 Highly toxic and toxic compressed gases—quantities exceeding the maximum allowable quantity per control area .................. 1101
29.6.2.9.8.2 Local exhaust for portable tanks ................................ 1101
29.6.2.10.2 Penetrations ......................................................... 1102
29.6.2.11.1 Projectors with an exhaust discharge ............................ 1102
29.6.2.11.2 Projectors without exhaust connection ........................... 1102
29.6.2.12 Organic coating processes .......................................... 1102
29.6.2.14 Motor vehicle operation ............................................. 1103
29.6.2.15 Repair garages ......................................................... 1103
29.6.2.16 Repair garages for vehicles fueled by lighter-than-air fuels .... 1103
29.6.2.16.2 Exhaust ventilation system ........................................ 1103
29.6.2.16.2.1 Design ............................................................ 1104
29.6.2.20 Manicure and pedicure stations .................................... 1104
29.6.3.1 General ................................................................. 1104
29.6.3.2 Fans ...................................................................... 1104
29.6.3.3 Equipment and appliance identification plate ....................... 1104
29.6.4 DOMESTIC COOKING EXHAUST EQUIPMENT ..................... 1105
29.6.4.3 Exhaust ducts .......................................................... 1105
29.6.4.4 Makeup air required .................................................. 1105
29.6.5 Commercial Kitchen Hood Ventilation System Ducts and Exhaust Equipment .................................................. 1106
29.6.5.3 Ducts serving Type I hoods .......................................... 1106
29.6.5.3.2.1 Duct joint types ................................................. 1107
29.6.5.3.2.3 Duct-to-exhaust fan connections ............................... 1107
29.6.5.3.4 Vibration isolation .................................................. 1108
29.6.5.3.5 Grease duct test ................................................... 1108
29.6.5.3.8.1 Personnel entry ................................................... 1109
29.6.5.3.11 Grease duct enclosures ........................................... 1110
29.6.5.3.11.1 Shaft enclosure ................................................ 1111
29.6.5.3.11.2 Field-applied grease duct enclosure .......................... 1111
29.6.5.3.11.3 Factory-built grease duct enclosure assemblies ............... 1111
29.6.5.3.12 Grease duct fire-resistant access opening ...................... 1111
29.6.5.3.13.2 Termination through an exterior wall ......................... 1111
29.6.5.3.13.3 Termination location ........................................... 1111
29.6.5.5.1.2 In-line fan location ............................................. 1112
29.6.5.5.2 Pollution-control units ............................................ 1112
29.6.5.5.3 Exhaust fan discharge ............................................. 1113
29.6.5.5.4 Exhaust fan mounting .............................................. 1113
29.6.6 COMMERCIAL KITCHEN HOODS .................................... 1114
29.6.6.1 General ............................................................... 1114
29.6.6.1.1 Operation ............................................................ 1114
29.6.6.2 Type I hoods .......................................................... 1115
29.6.12.13.1 Materials ................................................................. 1129
29.6.13 ENERGY RECOVERY VENTILATION SYSTEMS .................. 1130
29.6.13.1 General ................................................................. 1130
29.6.13.2 Systems ................................................................. 1130
29.7 BOILERS, WATER HEATERS AND PRESSURE VESSELS .......... 1130
29.7.1 GENERAL ................................................................. 1130
29.7.2 WATER HEATERS ......................................................... 1130
29.7.2.1 General ................................................................. 1130
29.7.3 PRESSURE VESSELS ....................................................... 1131
29.7.3.1 General ................................................................. 1131
29.7.4 BOILERS ................................................................. 1131
29.7.4.1 Standards ............................................................... 1131
29.7.4.2 Installation ............................................................. 1131
29.7.4.3 Working clearance .................................................. 1131
29.7.4.6 Boiler rooms and enclosures .................................. 1132
29.7.4.7 Operating adjustments and instructions ...................... 1132
29.7.5 BOILER CONNECTIONS .................................................. 1132
29.7.5.1 Valves ................................................................. 1132
29.7.5.6 SAFETY AND PRESSURE RELIEF VALVES AND CONTROLS ... 1132
29.7.6.4 Approval of safety and safety relief valves ................. 1133
29.7.6.6 Safety and relief valve discharge .............................. 1133
29.7.6.8 Electrical requirements ......................................... 1133
29.7.7 BOILER LOW-WATER CUTOFF ........................................ 1133
29.7.8 BOTTOM BLOWOFF VALVE ............................................ 1134
29.7.8.1 General ................................................................. 1134
29.7.8.2 Discharge .............................................................. 1134
29.7.9 HOT WATER BOILER EXPANSION TANK ......................... 1134
29.7.9.1 Where required ....................................................... 1134
29.7.9.3 Open-type expansion tanks ................................... 1134
29.7.10 GAUGES ................................................................. 1135
29.7.10.1 Hot water boiler gauges ....................................... 1135
29.7.11 TESTS ................................................................. 1135
29.7.11.1 Tests ................................................................. 1135
29.8 REFRIGERATION ............................................................ 1135
29.8.1 GENERAL ................................................................. 1135
29.8.1.1 Scope ................................................................. 1135
29.8.1.2 Factory-built equipment and appliances ................... 1135
29.8.1.8 Change in refrigerant type ................................... 1136
29.8.2 SYSTEM REQUIREMENTS ............................................ 1136
29.8.2.2.2 Purity ................................................................. 1136
29.8.2.2.2 Recovered refrigerants .................................... 1136
29.8.3 REFRIGERATION SYSTEM CLASSIFICATION ................ 1137
29.8.3.2 Occupancy classification ...................................... 1144
29.8.3.3 System classification ............................................ 1144
29.8.3.3.1 Low-probability systems ................................ 1144
29.8.4 SYSTEM APPLICATION REQUIREMENTS ..................... 1145
29.8.4.2 Machinery room ..................................................... 1145
29.8.4.2.1 Institutional occupancies ................................ 1145
29.8.4.2.2 Industrial occupancies and refrigerated rooms .... 1145
29.8.4.3.2 Nonindustrial occupancies ................................ 1146
29.8.4.3.4 Protection from refrigerant decomposition .......... 1146
29.8.4.4.1 Noncommunicating spaces ................................ 1147
29.8.4.4.3 Plenums ............................................................... 1147
29.8.4.5 MACHINERY ROOM, GENERAL REQUIREMENTS .......... 1147
29.8.5.6.2 Makeup air .......................................................... 1148
29.8.5.6.3 Ventilation rate .................................................... 1148
29.8.5.9 Emergency pressure control system ....................... 1149
29.8.6 MACHINERY ROOM, SPECIAL REQUIREMENTS .............. 1149
29.8.6.4 Flammable refrigerants .......................................... 1149
29.8.6.5.2 Emergency ventilation system ............................ 1149
29.8.6.5.3 Emergency ventilation system discharge .............. 1150
29.8.6.6.1 Refrigeration system emergency shutoff ................ 1150

lxxxvii
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.3.1.7</td>
<td>Materials and workmanship</td>
</tr>
<tr>
<td>30.3.1.8</td>
<td>Fixture traps and vent pipes</td>
</tr>
<tr>
<td>30.3.1.9</td>
<td>Foul air exhaust</td>
</tr>
<tr>
<td>30.3.1.10</td>
<td>Testing</td>
</tr>
<tr>
<td>30.3.1.11</td>
<td>Exclusion from plumbing system</td>
</tr>
<tr>
<td>30.3.1.12</td>
<td>Light and ventilation</td>
</tr>
<tr>
<td>30.3.1.13</td>
<td>Individual sewage disposal systems</td>
</tr>
<tr>
<td>30.3.1.14</td>
<td>Maintenance</td>
</tr>
<tr>
<td>30.3.1.15</td>
<td>Accessibility</td>
</tr>
<tr>
<td>30.3.1.16</td>
<td>Fixture for the disabled</td>
</tr>
<tr>
<td>30.3.1.17</td>
<td>Structural safety</td>
</tr>
<tr>
<td>30.3.1.18</td>
<td>Protection of ground and surface water</td>
</tr>
<tr>
<td>30.3.2</td>
<td>Water supply connection</td>
</tr>
<tr>
<td>30.3.2.1</td>
<td>Application for obtaining supply connection</td>
</tr>
<tr>
<td>30.3.2.2</td>
<td>Bulk supply</td>
</tr>
<tr>
<td>30.3.2.3</td>
<td>Completion certificate</td>
</tr>
<tr>
<td>30.3.3</td>
<td>Drainage and sanitation</td>
</tr>
<tr>
<td>30.3.3.1</td>
<td>Preparation and submission of plan</td>
</tr>
<tr>
<td>30.3.3.2</td>
<td>Site plan</td>
</tr>
<tr>
<td>30.3.3.3</td>
<td>Drainage plan</td>
</tr>
<tr>
<td>30.3.3.5</td>
<td>Completion certificate</td>
</tr>
<tr>
<td>30.3.4</td>
<td>Licencing/registration of plumbers</td>
</tr>
<tr>
<td>30.3.4.1</td>
<td>Execution of work</td>
</tr>
<tr>
<td>30.3.4.2</td>
<td>Examination and certification</td>
</tr>
<tr>
<td>30.4</td>
<td>Water supply</td>
</tr>
<tr>
<td>30.4.1</td>
<td>Water supply requirements for buildings</td>
</tr>
<tr>
<td>30.4.1.1</td>
<td>Water supply for residences</td>
</tr>
<tr>
<td>30.4.1.3</td>
<td>Water supply requirements of traffic terminal stations</td>
</tr>
<tr>
<td>30.4.1.4</td>
<td>Water supply for firefighting purposes</td>
</tr>
<tr>
<td>30.4.2</td>
<td>Water sources and quality</td>
</tr>
<tr>
<td>30.4.2.3</td>
<td>Waste water reclamation</td>
</tr>
<tr>
<td>30.4.3</td>
<td>Materials used</td>
</tr>
<tr>
<td>30.4.4</td>
<td>Materials, fittings and appliances</td>
</tr>
<tr>
<td>30.4.4.2</td>
<td>Materials for pipes</td>
</tr>
<tr>
<td>30.4.5</td>
<td>Design of distribution systems</td>
</tr>
<tr>
<td>30.4.5.1</td>
<td>General</td>
</tr>
<tr>
<td>30.4.5.2</td>
<td>Discharge computation</td>
</tr>
<tr>
<td>30.4.5.2.1</td>
<td>Design of consumer's pipes based on fixture units</td>
</tr>
<tr>
<td>30.4.5.2.2</td>
<td>Probable simultaneous demand</td>
</tr>
<tr>
<td>30.4.5.3</td>
<td>Pipe size computation</td>
</tr>
<tr>
<td>30.4.7</td>
<td>General requirements for pipe work</td>
</tr>
<tr>
<td>30.4.7.1</td>
<td>Service pipes</td>
</tr>
<tr>
<td>30.4.7.2</td>
<td>Consumer pipes</td>
</tr>
<tr>
<td>30.4.7.3</td>
<td>Prohibited connections</td>
</tr>
<tr>
<td>30.4.8</td>
<td>Jointing of pipes</td>
</tr>
<tr>
<td>30.4.8.1</td>
<td>Cast iron pipes</td>
</tr>
<tr>
<td>30.4.8.2</td>
<td>Steel pipes</td>
</tr>
<tr>
<td>30.4.8.3</td>
<td>Wrought iron and steel screwed pipes</td>
</tr>
<tr>
<td>30.4.8.4</td>
<td>Asbestos cement pipes</td>
</tr>
<tr>
<td>30.4.8.5</td>
<td>Asbestos cement pipes shall not be used</td>
</tr>
<tr>
<td>30.4.8.6</td>
<td>Concrete pipes</td>
</tr>
<tr>
<td>30.4.8.7</td>
<td>Polyethylene and unplasticized PVC pipes</td>
</tr>
<tr>
<td>30.4.9</td>
<td>Backflow prevention</td>
</tr>
<tr>
<td>30.4.10</td>
<td>Conveyance and distribution of water within the premises</td>
</tr>
<tr>
<td>30.4.12</td>
<td>Hot water supply installations</td>
</tr>
<tr>
<td>30.4.12.1</td>
<td>Design consideration</td>
</tr>
<tr>
<td>30.4.12.1.1</td>
<td>General</td>
</tr>
<tr>
<td>30.4.12.10</td>
<td>Cold water supply to heaters</td>
</tr>
<tr>
<td>30.4.12.10.2</td>
<td>Storage cisterns</td>
</tr>
<tr>
<td>30.4.12.11</td>
<td>Cold water feed</td>
</tr>
</tbody>
</table>
30.4.12.12 Hot water piping ................................................................. 1174
30.4.12.12.1 Expansion pipe or vent pipe ........................................... 1175
30.4.12.12.2 Hot water heaters ......................................................... 1175
30.4.13.2.3 Electrical connection..................................................... 1175
30.4.14 cleaning and disinfection of the supply system ....................... 1176
30.4.15 Water supply systems in high altitudes and/or sub-zero temperature regions ......................................................... 1176
30.4.15.1 Pumping Installation ......................................................... 1176
30.4.15.2 Transmission and Distribution ............................................ 1176
30.4.15.2.1 Materials for pipes ....................................................... 1176
30.5. PRELIMINARY DATA FOR DESIGN ............................................. 1176
30.5.1 General ............................................................................. 1176
30.5.2 Drainage into a public sewer ................................................. 1177
30.5.3 Other methods of disposal of sewage ...................................... 1177
30.5.4. Disposal of surface and sub-soil waters ................................. 1177
30.5.5 Planning and design considerations ......................................... 1178
30.5.5.1 General ......................................................................... 1178
30.5.5.5. Drainage (soil, waste and ventilating) pipes .......................... 1178
30.5.5.5.1 General considerations .................................................. 1178
30.5.5.5.2 Soil pipes .................................................................. 1178
30.5.5.5.8 Special wastes .............................................................. 1178
30.5.5.8.1 General .................................................................. 1178
30.5.5.8.2 Laboratory wastes ........................................................ 1179
PART 31: LIFT AND CONVEYING SYSTEMS ..................................... 1179
31.1 GENERAL ........................................................................... 1179
31.1.1 Scope ........................................................................... 1179
31.1.2 Definitions ...................................................................... 1179
31.1.3 General .......................................................................... 1185
31.1.3.2 Exchange of information .................................................. 1185
31.1.3.2.2 Information to be provided by Architect or Engineer ........ 1185
31.1.3.2.3 Working drawings to be prepared by the lift/escalator manufacturer ........................................ 1186
31.1.3.3 Electrical requirement ...................................................... 1186
31.1.3.4 Essential requirements ...................................................... 1187
31.1.4.3 Conformity with Ghana Standards ..................................... 1187
31.1.4.4 Conformity with Fire Regulations ..................................... 1187
31.1.4.5 Factor of safety ............................................................... 1187
31.1.4.6 Additional requirements for passenger and good lifts .......... 1187
31.1.4.6.1 Bottom and top car clearances ...................................... 1187
31.1.4.6.1.1 Bottom car clearance .............................................. 1187
31.1.4.6.1.2 Top car clearance .................................................... 1187
31.1.4.6.2 Bottom runby for cars and counterweights ..................... 1188
31.1.4.6.3 Maximum bottom runby ............................................... 1188
31.1.4.6.4 Top counterweight clearances ...................................... 1188
31.1.4.7 Additional requirements for service lifts .............................. 1188
31.1.4.7.1 Top and bottom clearances for car and counterweights ... 1188
31.1.4.7.1.1 Top car clearance .................................................... 1188
31.1.4.7.1.2 Bottom car clearance .............................................. 1188
31.1.4.7.1.3 Top counterweight clearance .................................... 1189
31.1.4.7.1.4 Runby for cars and counterweights ......................... 1189
31.1.4.7.1.5 Maximum bottom runby .......................................... 1189
31.1.4.9 Planning for dimensions ..................................................... 1189
31.1.4.9.1 General .......................................................... 1189
31.1.4.9.2 Plan dimensions .......................................................... 1189
31.1.4.9.3.2 Travel ................................................................. 1192
31.1.4.9.3.3 Pit ................................................................. 1192
31.1.4.9.3.4 Minimum floor to floor height ................................... 1192
31.1.4.10 Lift wells and lift well enclosures .................................... 1193
31.1.4.10.1 Lift wells ................................................................. 1193
31.1.4.10.2 Lift well enclosures .................................................... 1193
31.1.4.10.2.8 Indicator ............................................................... 1194
9.5.4.10.2.9 Landing doors ........................................................... 1194
31.1.4.10.2.10 Automatic devices for cutting off power ........................................ 1194
31.1.4.10.3 Lift pits .................................................................................................. 1194
31.1.4.10.3.1 A lift pit shall be provided at the bottom of every lift ....................... 1194
31.1.4.11 Machine rooms and overhead structures .............................................. 1194
31.1.4.12 Essential features required ..................................................................... 1195
31.1.5 Dimensional tolerances ............................................................................ 1196
31.1.5.1 Lift well dimensions ............................................................................. 1196
31.1.5.2 Landing door openings .......................................................................... 1196
31.1.5.3 Structural limits for lift wells at any level .............................................. 1196
31.1.6 Preliminary design .................................................................................... 1196
31.1.6.1 Number of lifts and capacity ................................................................. 1196
31.1.6.2 Preliminary lift planning ......................................................................... 1197
31.1.6.2.1 General .............................................................................................. 1197
31.1.6.2.2 Population ......................................................................................... 1197
31.1.6.2.3 Quantity of service .......................................................................... 1197
31.1.6.2.4 Quality of Service ............................................................................ 1198
31.1.6.2.5 Traffic peaks ...................................................................................... 1198
31.1.6.2.6 Capacity ............................................................................................ 1198
31.1.6.2.7 Speed ................................................................................................. 1198
31.1.6.2.8 Layout ............................................................................................... 1198
31.1.6.2.9 Determination of transport or handling capacity during the up peak .... 1198
31.1.6.2.9.1 The handling capacity is calculated by the following formula .......... 1198
31.1.7.2.9.2 An example illustrating the use of the above consideration is given below: 1199
31.1.7.3 Quiet operation of lifts ........................................................................... 1200
31.1.7.4 Positioning of lifts .................................................................................. 1200
31.1.6.4.1 Arrangement of lifts .......................................................................... 1200
31.1.6.4.2 Passenger lifts .................................................................................. 1200
31.1.6.4.2.1 Low and medium class flats .......................................................... 1200
31.1.6.4.2.2 Office buildings, hotels and high class flats .................................. 1200
31.1.6.4.2.3 Shops and departmental stores .................................................... 1200
31.1.7.4.3 Goods lifts ......................................................................................... 1201
31.1.7.4.4 Hospital bed lifts ............................................................................. 1201
31.1.7.4.5 Personnel and Material Hoists ........................................................ 1201
31.1.6.5 Structural considerations ...................................................................... 1201
31.1.6.5.2 Machine room .................................................................................. 1201
31.1.6.6 Access to machine room and lift pits .................................................. 1202
31.1.6.6.4 Access to a machine room via the lift well shall be prohibited.............. 1202
31.1.6.7 Fire protection ....................................................................................... 1202
31.1.6.8 Requirements for fireman’s lift ............................................................. 1202
31.1.6.8.1 Sequence of operation ...................................................................... 1203
31.1.6.9 Supply cables and switches .................................................................. 1203
31.1.7 Power and control systems ...................................................................... 1203
31.1.7.1 Feature associated with power systems ............................................... 1203
31.1.7.1.1 Industrial switchgear ........................................................................ 1203
31.1.7.1.2 Leveling accuracy ........................................................................... 1204
31.1.7.1.3 Corrective leveling .......................................................................... 1204
31.1.7.1.4 Leveling with variable voltage ......................................................... 1204
31.1.7.1.5 Overload tests ................................................................................. 1204
31.1.7.1.6 Occasional extra load ........................................................................ 1204
31.1.7.2 Description of operation systems ......................................................... 1204
31.1.7.2.1 Methods of control systems ............................................................. 1204
31.1.7.2.2 Automatic push button operation .................................................... 1204
31.1.7.2.3 Collective control ............................................................................ 1205
31.1.7.2.4 Single push button collective control .............................................. 1205
31.1.7.2.5 Down collective control .................................................................. 1205
31.1.7.2.6 Directional collective control for one car ........................................ 1205
31.1.7.2.7 Directional collective control for two or three cars ......................... 1206
31.1.7.2.8 Group supervisory control ............................................................... 1206
31.1.7.3 Features of operation systems ............................................................... 1206
31.1.7.3.1 Car preference .................................................................................. 1206
31.1.7.3.2 Landing call automatic bypass ......................................................... 1206
31.1.7.3.3 Motor generator shut down ................................................................. 1207
31.1.7.3.4 Basement service .............................................................................. 1207
31.1.7.3.5 Hospital service ................................................................................ 1207
31.1.7.3.6 Manually operated doors (without closers) ....................................... 1207
31.1.7.3.7 Automatically power closed doors ..................................................... 1207
31.1.7.3.8 Controlled power closed doors ........................................................... 1207
31.1.7.3.9 Safe operation of doors ..................................................................... 1207
31.1.7.3.10 Director service ................................................................................ 1207
31.1.7.3.11 Indication of car arrival .................................................................... 1207
31.1.7.3.12 Service switches .............................................................................. 1208
31.1.7.3.13 Fire switch ....................................................................................... 1208
31.1.7.3.14 Push buttons and signals .................................................................. 1208
31.1.7.4 Electrical installation requirements ....................................................... 1208
31.1.7.4.1 General .............................................................................................. 1208
31.1.7.4.2 Electric wiring and apparatus ............................................................... 1208
31.1.7.4.3 Emergency signal or telephone ........................................................ 1209
31.1.7.4.4 Earthing ............................................................................................ 1209
31.1.7.5 Building management systems – interface for lifts ......................... 1209
31.1.8 Conditions for optimum practice .............................................................. 1210
31.1.8.1 Lift entrance operation ......................................................................... 1210
31.1.8.1.1 General ............................................................................................. 1210
31.1.8.1.2 Goods traffic ..................................................................................... 1210
31.1.8.2 Planning at works and on site ............................................................... 1211
31.1.8.3 Special environments ......................................................................... 1211
31.1.8.4 Ventilation of machine rooms ............................................................... 1211
31.1.8.5 Lighting and treatment of walls, floors, etc. ....................................... 1211
31.1.8.6 Stairwell enclosures ............................................................................... 1212
31.1.8.7 Hand-winding release procedure and indication .................................. 1212
31.1.9 Escalators .................................................................................................. 1212
31.1.9.2 Essential requirements ......................................................................... 1213
31.1.9.2.4 Handrails .......................................................................................... 1214
31.1.9.2.6 Landing ............................................................................................. 1214
31.1.9.2.7 Compliance ....................................................................................... 1214
31.1.9.2.8 Trusses or girders ............................................................................. 1214
31.1.9.2.9 Step wheel tracks ............................................................................. 1214
31.1.9.2.10 Driving machine, motor and brake ................................................. 1214
31.1.9.2.10.2 An electric motor shall not drive more than one escalator .......... 1214
31.1.9.2.10.4 Speed governor ............................................................................ 1214
PART 32: SPECIAL CONSTRUCTION ............................................................... 1216
32.1 GENERAL ..................................................................................................... 1216
32.1.1 Scope. ........................................................................................................ 1216
32.2 MEMBRANE STRUCTURES ........................................................................ 1216
32.2.1 General. .................................................................................................... 1216
32.2.2 Tensile membrane structures and air-supported structures .................. 1216
32.2.3 Type of construction. ................................................................................ 1216
32.2.3.1 Membrane and interior liner material. ................................................ 1216
32.2.4 Allowable floor areas. ................................................................................ 1216
32.2.5 Maximum height. ..................................................................................... 1216
32.2.6 Mixed construction. .................................................................................. 1216
32.2.6.1 Noncombustible membrane ................................................................. 1216
32.2.6.1.1 Membrane. ....................................................................................... 1217
32.2.7 Engineering design. .................................................................................. 1217
32.2.7.1 Lateral restraint. ................................................................................... 1217
32.2.8 Inflation systems. ...................................................................................... 1217
32.2.8.1 Equipment requirements ....................................................................... 1217
32.2.8.1.1 Auxiliary inflation system ................................................................. 1217
32.2.8.1.2 Blower equipment ............................................................................. 1217
32.2.8.3 Support provisions. ............................................................................... 1217
32.3 TEMPORARY STRUCTURES ................................................................. 1217
32.3.1 General. .................................................................................................... 1217

xcii
32.4.3 Construction.......................................................................................................................... 1218
32.4.4 Contents.................................................................................................................................. 1218
32.4.5 Connections of pedestrian walkways to buildings .................................................................. 1218
32.4.5.1 Fire barriers......................................................................................................................... 1219
32.4.5.1.1 Exterior walls..................................................................................................................... 1219
32.4.5.1.2 Openings in exterior walls of connected buildings............................................................. 1219
32.4.5.1.3 Supporting construction..................................................................................................... 1219
32.4.5.2 Alternative separation.......................................................................................................... 1219
32.4.5.2.1 Passage of smoke.............................................................................................................. 1219
32.4.5.2.2 Glass.................................................................................................................................. 1219
32.4.5.3 Open sides on walkway.......................................................................................................... 1219
32.4.5.4 Exterior walls with fire rating greater than 2 hours............................................................... 1219
32.4.6 Public way............................................................................................................................... 1220
32.4.7 Escape..................................................................................................................................... 1220
32.4.8 Width........................................................................................................................................ 1220
32.4.9 Exit access travel..................................................................................................................... 1220
32.4.10 Tunneld walkway.................................................................................................................. 1220
32.5 AWNINGS AND CANOPIES ....................................................................................................... 1220
32.5.1 General...................................................................................................................................... 1220
32.5.2 Design and construction........................................................................................................ 1220
32.5.3 Awnings and canopy materials.............................................................................................. 1220
32.6 MARQUEES ............................................................................................................................... 1220
32.6.1 General...................................................................................................................................... 1220
32.6.2 Thickness.................................................................................................................................. 1221
32.6.3 Roof construction.................................................................................................................... 1221
32.6.4 Location prohibited.................................................................................................................. 1221
32.6.5 Construction............................................................................................................................. 1221
32.7 SIGNS ......................................................................................................................................... 1221
32.7.1 General...................................................................................................................................... 1221
32.8 TELECOMMUNICATION AND BROADCAST TOWERS ............................................................... 1221
32.8.1 General...................................................................................................................................... 1221
32.8.2 Location and access.................................................................................................................. 1221
32.9 SWIMMING POOLS, SPAS AND HOT TUBS ............................................................................... 1221
32.9.1 General...................................................................................................................................... 1221
32.10 AUTOMATIC VEHICULAR GATES ............................................................................................ 1221
32.10.1 General.................................................................................................................................... 1221
32.10.2 Vehicular gates intended for automation............................................................................... 1221
32.10.3 Vehicular gate openers........................................................................................................... 1221
32.11 SOLAR ENERGY SYSTEMS ..................................................................................................... 1221
32.11.1 General.................................................................................................................................... 1221
32.11.1.1 Wind resistance................................................................................................................... 1221
32.11.1.2 Roof live load..................................................................................................................... 1221
32.11.2 Solar thermal systems.......................................................................................................... 1222
32.11.2.1 Equipment......................................................................................................................... 1222
32.11.3 Photovoltaic solar energy systems........................................................................................ 1222
32.11.3.1 Equipment........................................................................................................................ 1222
32.11.3.2 Fire classification................................................................................................................. 1222
32.11.3.3 Building-integrated photovoltaic systems......................................................................... 1222
32.11.3.4 Access and pathways......................................................................................................... 1222
32.11.3.5 Ground-mounted photovoltaic systems............................................................................ 1222
32.11.3.5.1 Fire separation distances.............................................................................................. 1222
32.12 GREENHOUSES ....................................................................................................................... 1222
32.12.1 General. .................................................................................................................... 1222
32.12.2 Accessibility. ............................................................................................................. 1222
32.12.3 Structural design. ..................................................................................................... 1222
32.12.4 Glass and glazing. ................................................................................................... 1222
32.12.5 Light-transmitting plastics ..................................................................................... 1222
32.12.6 Membrane structures. ............................................................................................. 1222
32.12.6.1 Plastic film ........................................................................................................... 1222
32.13 RELOCATABLE BUILDINGS ..................................................................................... 1222
32.13.1 General. .................................................................................................................. 1222
32.13.1.1 Compliance. ........................................................................................................ 1222
32.13.2 Supplemental information. ..................................................................................... 1222
32.13.3 Manufacturer’s data plate. ..................................................................................... 1223
32.13.4 Inspection agencies. ............................................................................................... 1223
32.14 ................................................................................................................................... 1223
32.14.1 Exterior walls-one-storey buildings. .................................................................... 1223
32.14.2 Roofing ................................................................................................................... 1223
32.14.3 Attics and crawl spaces. ........................................................................................ 1223
32.14.4 Doors not required to have a fire protection rating. ............................................ 1224
32.14.4.4 Exterior doors in buildings of Group R-2 or R-3 ..................................................... 1224
32.14.4.5 Garage doors ....................................................................................................... 1224
32.14.5 Siding backer board............................................................................................... 1224
PART 33: ENCROACHMENTS INTO THE PUBLIC RIGHT-OF-WAY .................................. 1224
33.1 GENERAL ..................................................................................................................... 1225
33.1.1 Scope. ....................................................................................................................... 1225
33.2 ENCROACHMENTS ...................................................................................................... 1225
33.2.1 Measurement. ......................................................................................................... 1225
33.2.2 Other IEN 310. ......................................................................................................... 1225
33.2.3 Drainage .................................................................................................................. 1225
33.2.4 Encroachments below grade. .................................................................................. 1225
33.2.4.1 Structural support. .............................................................................................. 1225
33.2.5.2 Vaults and other enclosed spaces. .................................................................... 1225
33.2.5.3 Areaways. .......................................................................................................... 1225
33.2.5.4 Encroachments above grade and below 8 feet in height ................................... 1225
33.2.6.1 Steps. ................................................................................................................... 1225
33.2.6.2 Architectural features. ........................................................................................ 1225
33.2.6.3 Awnings. ............................................................................................................. 1225
33.2.7 Encroachments 8 feet or more above grade. ......................................................... 1226
33.2.7.1 Awnings, canopies, marquees and signs. ............................................................ 1226
33.2.7.2 Windows, balconies, architectural features and mechanical equipment. ........ 1226
33.2.7.3 Pedestrian walkways .......................................................................................... 1226
PART 34: SAFEGUARDS DURING CONSTRUCTION ....................................................... 1226
34.1 GENERAL ..................................................................................................................... 1226
34.1.1 Scope. ....................................................................................................................... 1226
34.1.2 Storage and placement. .......................................................................................... 1226
34.2 CONSTRUCTION SAFEGUARDS ............................................................................. 1227
34.2.1 Alterations, repairs and additions. ......................................................................... 1227
34.2.2 Manner of removal. ............................................................................................... 1227
34.3 DEMOLITION ............................................................................................................. 1227
34.3.1 Construction documents. ....................................................................................... 1227
34.3.2 Pedestrian protection. ............................................................................................ 1227
34.3.3 Means of Escape .................................................................................................... 1227
34.3.4 Vacant plot. ............................................................................................................ 1227
34.3.5 Water accumulation. .............................................................................................. 1227
34.3.6 Utility connections. ............................................................................................... 1227
34.3.7 Fire safety during demolition. ................................................................................ 1227
34.4 SITE WORK ................................................................................................................ 1227
34.4.1 Excavation and fill. ............................................................................................... 1227
34.4.1.1 Slope limits. ....................................................................................................... 1227
34.4.1.2 Surcharge. .......................................................................................................... 1227
34.4.1.3 Footings on adjacent slopes. ............................................................................. 1228
34.4.1.4 Fill supporting foundations. .............................................................................. 1228
xciv
34.5 SANITARY ................................................................. 1228
34.5.1 Facilities required ................................................. 1228
34.6 PROTECTION OF PEDESTRIANS .................................. 1228
34.6.1 Protection required .............................................. 1228
34.6.2 Walkways ........................................................... 1228
34.6.3 Directional barricades ........................................... 1228
34.6.4 Construction railings ............................................ 1228
34.6.5 Barriers ............................................................. 1228
34.6.6 Barrier design .................................................... 1228
34.6.7 Covered walkways ............................................... 1228
34.6.8 Repair, maintenance and removal ......................... 1229
34.6.9 Adjacent to excavations ....................................... 1229
34.7 PROTECTION OF ADJOINING PROPERTY ..................... 1229
34.7.1 Protection required ............................................. 1229
34.8 TEMPORARY USE OF STREETS, ALLEYS AND PUBLIC PROPERTY ........................................... 1229
34.8.1 Storage and handling of materials ......................... 1229
34.8.1.1 Obstructions .................................................. 1230
34.8.2 Utility fixtures .................................................. 1230
34.9 FIRE EXTINGUISHERS ............................................. 1230
34.9.1 Where required ................................................. 1230
34.9.2 Fire hazards ..................................................... 1230
34.10 MEANS OF ESCAPE .............................................. 1230
34.10.1 Stairways required ............................................ 1230
34.10.2 Maintenance of means of escape ......................... 1230
34.11 STANDPIPES ....................................................... 1230
34.11.1 Where required ............................................... 1230
34.11.2 Buildings being demolished ............................... 1230
34.11.3 Detailed requirements ....................................... 1230
34.12 AUTOMATIC SPRINKLER SYSTEM ............................ 1231
34.12.1 Completion before occupancy ............................. 1231
34.12.2 Operation of valves .......................................... 1231
34.13 WATER SUPPLY FOR FIRE PROTECTION .................. 1231
34.13.1 Where required ............................................... 1231
34.14 FIRE WATCH DURING CONSTRUCTION ...................... 1231
34.14.1 Fire watch during combustible construction .......... 1231
34.15 GENERAL HEALTH SAFETY AND ENVIRONMENT ........ 1231
PART 35: SMALL BUILDINGS ............................................. 1232
35.1 GENERAL ............................................................. 1232
35.1.1 Scope ................................................................ 1232
35.2 MATERIALS, SYSTEMS AND EQUIPMENT .................... 1232
35.2.1 General ............................................................. 1232
35.2.1.1 Performance ............................................... 1232
35.2.1.2 Required Tests ............................................ 1232
35.2.1.3 Published Test Methods ................................ 1232
35.2.1.4 Assessment of Materials, Systems and Equipment 1232
35.2.1.5 Absence of Published Test Methods ................ 1232
35.2.1.6 Testing Laboratories ..................................... 1232
35.2.1.7 Conflict with Reference Documents ................ 1232
35.2.1.8 Short-lived or Otherwise Unsuitable Materials .... 1232
35.2.2 Concrete .......................................................... 1232
35.2.3 Timber and wood products .................................. 1233
35.2.4 Metal ............................................................... 1233
35.3 LOADS ................................................................. 1233
35.3.1 General ............................................................. 1233
35.3.2 Floor loads ........................................................ 1233
35.3.3 Roof live loads other than wind loads or rain loads ... 1234
35.3.4 Wind loads ....................................................... 1234
35.3.5 Deflections ........................................................ 1234
35.3.6 Earthquake loads ............................................... 1234
35.4 ROOM AND SPACE DIMENSIONS ............................. 1235
35.4.1 General ............................................................. 1235
35.4.2 Ceiling heights
35.4.2.1 Room heights
35.4.3 Living rooms or Spaces within dwelling units
35.4.3.1 Living room area
35.4.4 Dining rooms or spaces within dwelling units
35.4.5 Kitchen within dwelling units
35.4.5.1 Kitchen area
35.4.6 Bedroom or space in dwelling units
35.4.6.1 Main bedroom area
35.4.6.2 Other bedroom areas
35.4.6.3 Combination bedroom areas
35.4.7 Bathrooms and water-closet rooms
35.4.7.1 Bathroom areas
35.4.8 Hallways
35.4.8.1 Width of hallways
35.5 DOORS
35.5.1 Door in fire separations
35.5.2 Required doors
35.5.2.1 Required doors in single dwelling units
35.5.2.2 Required doors in multiple dwelling units
35.5.3 Doorway sizes
35.5.3.1 Doorway openings
35.5.4 Exterior doors
35.5.5 Interior doors
35.5.7 Garage doors
35.6 WINDOWS
35.6.1 Scope
35.6.1.1 Natural lighting
35.6.1.3 Ventilation
35.6.2 General
35.6.2.1 Window design
35.6.2.2 Minimum window glass area
35.6.2.3 Windows in public spaces
35.6.3 Glass
35.6.4 Sealing
35.6.4.1 Sealing
35.6.5 Windows in Public areas
35.7 STAIRS, RAMPS, HANDRAILS AND GUARDS
35.7.1 Scope
35.7.1.1 Design and construction of stairs
35.7.1.2 Stairs as part of exit
35.7.2 General
35.7.2.1 Definitions
35.7.3 Private stairways
35.7.4 Common stairways
35.7.5 Tapered steps
35.7.6 Landings
35.7.6.1 Landings
35.7.6.2 Door Swing on Stairs
35.7.7. Ramps
35.7.7.1 Maximum gradient for ramps
35.7.7.2 Level area in ramps
35.7.8 Handrails
35.7.9 Guards
35.7.10 Construction
35.7.10.1 Wooden stair stringers
35.7.10.2 Wooden treads
35.7.10.3 Tread finish
35.7.10.4 Non-skid finish
35.8 MEANS OF ESCAPE
35.8.1 Scope
35.12.2 Installation
35.12.1 Water
35.11.1.1 Water-proofing of walls
35.11.1.2 Damp proofing of Walls
35.12 DRAINAGE
35.12.1 Scope
35.12.1.1 Drainage
35.12.1.2 Floor Slabs
35.12.2 Installation
35.12.2.2 Granular cover
35.12.3 Drainage disposal
35.16.3 Mortar ................................................................. 1255
35.16.3.1 Lime ............................................................ 1255
35.16.3.2 Mortar mixes .............................................. 1255
35.16.4 Mortar joints ..................................................... 1255
35.16.4.1 Mortar joint thickness ................................. 1255
35.16.4.2 Solid masonry joints ................................. 1255
35.16.4.3 Hollow masonry joints ............................. 1255
35.16.5 Masonry support ................................................ 1255
35.16.5.1 Masonry support ........................................ 1255
35.16.5.2 Lintels ......................................................... 1255
35.16.5.3 Every masonry wall shall be at least as thick as the wall it supports........... 1255
35.16.5.4 Thickness and height .................................. 1255
35.16.5.5 Thickness of solid external walls............... 1255
35.16.5.6 Thickness of interior walls ......................... 1255
35.16.6.3 Interior non-loadbearing partitions shall be not less than 70mm thick........ 1255
35.16.6.4 Masonry finish ....................................... 1255
35.16.6.5 Parapet walls ........................................... 1255
35.16.7 Chases and recesses ....................................... 1255
35.16.7.1 Size of chases and recesses ......................... 1255
35.16.7.2 Location of chases and recesses .................. 1255
35.16.7.3 Oversized chases and recesses ................. 1256
35.16.8 Support of loads ............................................. 1256
35.16.8.1 Capping of walls .................................... 1256
35.16.8.2 Bearing area ....................................... 1256
35.16.8.3 Interior non-loadbearing partitions shall be not less than 70mm thick........ 1255
35.16.8.4 Masonry finish ....................................... 1255
35.16.9 Lateral support ............................................... 1256
35.16.9.1 Lateral support of masonry walls ................ 1256
35.16.10 Exterior finish ............................................... 1256
35.16.10.1 Sandcrete Block Exterior Finish ............... 1256
35.16.11 Reinforcement for earthquake resistance ... 1256
35.17 WOOD-FRAME CONSTRUCTION ................................ 1256
35.17.1 Scope .............................................................. 1256
35.17.1.1 Wood-frame construction ................................ 1256
35.17.1.2 Design live load ..................................... 1256
35.17.2 General .......................................................... 1256
35.17.2.1 Rigidity .................................................. 1257
35.17.2.2 Treatment of end members ......................... 1257
35.17.3 Nails and staples .......................................... 1257
35.17.3.1 Nails and staples specification ................. 1257
35.17.3.2 Nail length ............................................ 1257
35.17.4 Allowable spans ............................................ 1257
35.17.5 Notching and drilling .................................... 1257
35.17.5.1 Notches and drilling ................................ 1257
35.17.6 Anchorage .......................................................... 1257
35.17.6.1 Anchorage ............................................ 1257
35.17.7 Sill plates .................................................... 1257
35.17.7.1 Sill plates ............................................ 1257
35.17.8 Beams to support floors ................................. 1258
35.17.8.1 Beams .................................................. 1258
35.17.8.2 Built-up wood beams .............................. 1258
35.17.9 Floor joists ....................................................... 1258
35.17.9.5 Double joists .......................................... 1258
35.17.9.7 Support of non-loadbearing partitions ........ 1258
35.17.9.9 Support of loadbearing partitions ........... 1258
35.17.9.10 Location of loadbearing interior walls ...... 1258
35.17.10 Wall studs ....................................................... 1259
35.17.10.1 Wall studs ............................................ 1259
35.17.10.2 Position of wall studs ............................. 1259
35.17.10.3 Design of corners and interclauses .......... 1259
35.17.10.4 Double studs .......................................... 1259
35.17.10.5 Single studs ........................................... 1259
35.17.10.6 The size and spacing of studs shall conform to Table 35.17.10. A .......... 1259
35.17.11 Wall plates ................................................................. 1259
35.17.11.1 Wall plates ............................................................. 1259
35.17.11.2 Bottom wall plates .................................................. 1259
35.17.11.3 Top plates in loadbearing walls ................................. 1259
35.17.11.6 Joints in top plates .................................................. 1260
35.17.11.7 Tying of top plates at corners ................................... 1260
35.17.12 Framing over openings ................................................ 1260
35.17.13 Bracing ................................................................. 1260
35.18 POST BEAM AND PLANK CONSTRUCTION ........................ 1260
35.18.1 Scope ......................................................................... 1260
35.18.2 General ................................................................. 1260
35.18.3 Decking ................................................................. 1260
35.18.3.1 Specifications for floor and roof decking ....................... 1260
35.18.3.2 Plank floor decking .................................................. 1260
35.18.4 Loadbearing beams ..................................................... 1260
35.18.5 Posts ......................................................................... 1261
35.18.5.1 Posts shall be solid, built-up or laminated ...................... 1261
35.18.5.2 Exterior wall post ..................................................... 1261
35.18.5.3 Built-up posts .......................................................... 1261
35.18.5.4 Intermediate studs .................................................... 1261
35.18.6 Plank frame wall construction ........................................ 1261
35.19 ROOFING ................................................................. 1262
35.19.1 General ................................................................. 1262
35.19.1.1 Roof protection ....................................................... 1262
35.19.2 Roofing materials ........................................................ 1262
35.19.2.1 Materials specification ............................................. 1262
35.19.2.2 Roofing nails .......................................................... 1262
35.19.2.3 Roofing staples ........................................................ 1262
35.19.3 Roof slope ............................................................... 1262
35.19.3.1 Roof slopes ............................................................ 1262
35.19.4 Flashing at interclauses .................................................. 1262
35.19.4.2 Valley flashing ........................................................ 1262
35.19.4.3 Open valley flashing ................................................. 1262
35.19.4.4 Closed valley flashing ............................................. 1263
35.19.4.5 Interclause flashing .................................................. 1263
35.19.5 Wood roof shingles ..................................................... 1263
35.19.5.1 Decking ............................................................... 1263
35.19.5.2 Size ..................................................................... 1263
35.19.5.3 Spacing ................................................................. 1263
35.19.5.4 Fastening ............................................................... 1263
35.19.5.5 Exposure ............................................................... 1263
35.19.5.6 Flashing ................................................................. 1263
35.19.6 Handsplit roof shakes ................................................... 1263
35.19.6.1 Size of shakes ........................................................ 1263
35.19.6.2 Spacing of shakes .................................................... 1263
35.19.6.3 Fastening of shakes .................................................. 1263
35.19.6.4 Exposure of shakes .................................................. 1263
35.19.6.5 Flashing ................................................................. 1263
35.20 INTERIOR WALL AND CEILING FINISHES ...................... 1263
35.20.1 General ................................................................. 1263
35.20.2 Waterproof wall finish .................................................. 1264
35.20.2.1 Waterproofing of interior finishes ............................... 1264
35.20.2.2 Waterproof finish ..................................................... 1264
35.20.3 Plywood finish ........................................................... 1264
35.20.3.1 Plywood finish thickness .......................................... 1264
35.20.3.3 Nails for plywood finish ........................................... 1264
35.20.3.4 All plywood edges shall be supported by furring, blocking or framing .................................................. 1264
35.20.4 Wall tile ................................................................. 1264
35.20.4.1 Wall tile base and adhesive ........................................ 1264
35.20.4.2 Mortar for ceramic tile ............................................. 1264
35.20.4.3 Adhesive for ceramic tile .......................................... 1264
35.21 FLOORING .................................................................................................................................................. 1264
35.21.1 General .................................................................................................................................................. 1264
35.21.1.1 Finished flooring shall be provided in all residential occupancies. .............................................. 1264
35.21.1.2 Finished flooring materials ........................................................................................................... 1264
35.21.1.3 Wood sleeper .................................................................................................................................. 1264
35.21.2 Wood strip flooring .......................................................................................................................... 1265
35.21.2.1 Dimensions .................................................................................................................................... 1265
35.21.2.2 Underlay ....................................................................................................................................... 1265
35.21.2.3 Laying of wood strip flooring ....................................................................................................... 1265
35.21.2.4 Nailing ......................................................................................................................................... 1265
35.21.3 Parquet flooring ................................................................................................................................... 1265
35.21.4 Ceramic tile ......................................................................................................................................... 1265
35.22 PLUMBING FACILITIES ...................................................................................................................... 1265
35.22.1 Scope .................................................................................................................................................. 1265
35.22.2 Water supply and distribution ........................................................................................................... 1265
35.22.2.1 Portable water .............................................................................................................................. 1265
35.22.2.2 Piping facilities ............................................................................................................................ 1265
35.22.3 Required facilities ............................................................................................................................ 1265
35.22.4 Sewage disposal ................................................................................................................................ 1266
35.23 VENTILATION ........................................................................................................................................ 1266
35.23.1 Scope .................................................................................................................................................. 1266
35.23.2 Natural ventilation .............................................................................................................................. 1266
35.23.3 Ventilation openings onto courts ....................................................................................................... 1266
35.23.4 Ventilation of larders ......................................................................................................................... 1267
35.23.4.3 Ventilators used for the ventilation of larders shall be: ................................................................ 1267
35.23.5 Ventilation of common stairways ..................................................................................................... 1267
35.24 ELECTRICAL FACILITIES ................................................................................................................ 1267
35.24.1 General .............................................................................................................................................. 1267
35.24.2 Lighting outlets .................................................................................................................................... 1267
35.24.2.1 Exterior lighting ............................................................................................................................ 1267
35.24.2.2 Requirements for lighting outlets .................................................................................................. 1267
35.24.2.4 Lights in stairways ......................................................................................................................... 1267
35.24.2.5 Storage room .................................................................................................................................. 1267
35.24.2.6 Lighting of garages and carports ................................................................................................. 1267
35.24.2.7 Lighting in public areas .................................................................................................................. 1268
PART 36: EXISTING BUILDINGS .................................................................................................................. 1269
PART 37: GREEN BUILDING REQUIREMENTS .......................................................................................... 1270
37.1 Scope ....................................................................................................................................................... 1270
37.2 DEFINITIONS .......................................................................................................................................... 1270
37.3 PRESCRIPTIVE COMPLIANCE PATH ..................................................................................................... 1270
37.3.1 Energy Efficiency Requirements ........................................................................................................ 1270
37.3.1.1 Building Envelope Properties ........................................................................................................ 1270
37.3.1.1.1 Window to Wall Ratio (WWR): .................................................................................................... 1270
37.3.1.1.2 Solar Heat Gain Co-efficient (SHGC) of the Glazing: ................................................................. 1270
37.3.1.1.3 Exterior Shading: ....................................................................................................................... 1270
37.3.1.2 Openable windows .......................................................................................................................... 1271
37.4 HEATING, VENTILATION AND AIR-CONDITIONING ......................................................................... 1271
37.4.1 Energy Efficiency of Air-conditioning Equipment ............................................................................ 1271
37.4.2 Variable Speed Drives ........................................................................................................................ 1273
37.5 LIGHTING AND ELECTRICAL POWER .................................................................................................. 1273
37.5.1 Lighting control system ........................................................................................................................ 1273
37.5.2 Energy efficient lighting system .......................................................................................................... 1274
37.5.3 Residential Energy efficient lighting system ....................................................................................... 1274
37.6 WATER EFFICIENCY ............................................................................................................................. 1275
37.6.1 Water efficient fittings ........................................................................................................................ 1275
37.6.2 Rain-water harvesting ........................................................................................................................ 1275
37.6.3 Stormwater Management ................................................................................................................... 1275
37.6.3.1 Metering of Groundwater consumption ....................................................................................... 1275
37.6.3.2 Minimum Open Unpaved Area ....................................................................................................... 1276
37.6.3.3 Permeable Paving for Parking ........................................................................................................ 1276
37.7 WASTEWATER MANAGEMENT ........................................................................................................... 1276
G1.4.3 Geotechnical report. ................................................................. 1308
G1.4.4 Liquefaction study. ............................................................... 1308
G1.5 INSPECTIONS ........................................................................... 1308
G1.6 EXCAVATIONS ......................................................................... 1308
G1.6.1 Maximum slope ...................................................................... 1308
G1.7 FILLS ......................................................................................... 1308
G1.7.1 General ................................................................................. 1308
G1.7.2 Surface preparation ............................................................... 1309
G1.7.4 Fill material ........................................................................... 1309
G1.7.5 Compaction .......................................................................... 1309
G1.7.6 Maximum slope ...................................................................... 1309
G1.8 SETBACKS ................................................................................. 1309
G1.8.1 General ................................................................................. 1309
G1.8.2 Top of slope .......................................................................... 1310
G1.8.3 Slope protection ...................................................................... 1310
G1.9 DRAINAGE AND TERRACING .................................................. 1310
G1.9.1 General ................................................................................. 1310
G1.9.2 Terraces ............................................................................... 1310
G1.9.3 Interceptor drains ................................................................. 1311
G1.9.4 Drainage across property lines ............................................. 1311
G1.10 EROSION CONTROL ............................................................... 1311
G1.10.1 General .............................................................................. 1311
G1.10.2 Other devices ...................................................................... 1311
G1.11 REFERENCED STANDARDS .................................................... 1311
APPENDIX H: EARTHQUAKE RECORDING INSTRUMENTATION ........ 1311
H1.1 GENERAL ................................................................................. 1311
H1.1.1 General ................................................................................ 1312
H1.1.2 Location .............................................................................. 1312
H1.1.3 Maintenance ........................................................................ 1312
APPENDIX I: COASTAL EROSION .................................................. 1312
I.1 CLAUSE I.2 CODE DEFINITIONS .............................................. 1312
I.3 ZONES ......................................................................................... 1314
I.4 FOUNDATION DESIGN .............................................................. 1316
I.5 STORM LOADS ........................................................................... 1316
I.6 EXCAVATIONS ........................................................................... 1317
APPENDIX J: REPLICABLE BUILDINGS ...................................... 1319
J1.1 ADMINISTRATION ..................................................................... 1319
J1.1.2 Objectives ........................................................................... 1319
J1.1.2 DEFINITIONS ......................................................................... 1319
J1.1.3 REPLICA BLE DESIGN REQUIREMENTS ............................ 1319
J1.1.3.1 Prototypical construction documents ................................ 1319
J1.4 REPLICA BLE DESIGN SUBMISSION REQUIREMENTS ......... 1319
J1.4.1 General ............................................................................... 1319
J1.4.1.1 Architectural plans and specifications ............................... 1319
J1.4.1.2 Structural plans, specifications and engineering details .... 1320
J1.4.1.3 Energy conservation details ............................................. 1320
J1.5 REVIEW AND APPROVAL OF REPLICA BLE DESIGN ....... 1320
J1.5.1 General ................................................................................. 1320
J1.5.2 Documentation ...................................................................... 1320
J1.5.3 Deficiencies .......................................................................... 1320
J1.5.4 Approval .............................................................................. 1321
J1.6 SITE-SPECIFIC APPLICATION OF APPROVED REPLICA BLE DESIGN ........................................... 1321
J1.6.1 General ............................................................................... 1321
J1.6.2 Submission documents ........................................................ 1321
J1.7 SITE-SPECIFIC REVIEW AND APPROVAL OF REPLICA BLE DESIGN .................................................... 1321
J1.7.2 Site-specific review and approval of replicable design .......... 1321
BIBLIOGRAPHY .................................................................................. 1322
PART 1: SCOPE AND ADMINISTRATION

User notes:
About this Part: Part 1 establishes the limits of applicability of the Code and describes how the Code is to be applied and enforced. This Code is intended to be adopted as a legally enforceable document and it cannot be effective without adequate provisions for its administration and enforcement. The provisions of Part 1 establish the authority and duties of the Code official appointed by the authority having jurisdiction and also establish the rights and privileges of the design professional, contractor and property owner. Part 1 is largely concerned with maintaining “due process of law” in enforcing the building performance criteria contained in the body of the Code.

SCOPE AND APPLICATION

1 GENERAL

1.1 Title.

These regulations shall be known as the Building Code of the Republic of Ghana hereinafter referred to as “this Code.”

1.1.2 Scope.

The provisions of this Code shall apply to the construction, alteration, relocation, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building structure or any appurtenances connected or attached to such buildings or structures.

Exception: Detached one- and two-family dwellings and townhouses not more than three stories above grade plane in height with a separate means of escape, and their accessory structures not more than three stories above grade plane in height, shall comply with this Code or the Ghana Residential Code.

1.1.2.1 Appendices.

Provisions in the appendices shall not apply unless specifically adopted.

1.1.3 Intent.

The purpose of this Code is to establish the minimum requirements to provide a reasonable level of safety, public health and general welfare through structural strength, means of escape facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire, explosion and other hazards, and to provide a reasonable level of safety to fire fighters and emergency responders during emergency operations.

1.1.4 Referenced Codes.

The other Codes listed in Clauses 1.1.4.1 through 1.1.4.7 and referenced elsewhere in this Code shall be considered to be part of the requirements of this Code to the prescribed extent of each such reference.

1.1.4.1 Gas.

The provisions of this Code shall apply to the installation of gas piping from the point of delivery, gas appliances and related accessories as covered in this Code. These requirements apply to gas piping systems extending from the point of delivery to the inlet connections of appliances and the installation and operation of residential and commercial gas appliances and related accessories.

1.1.4.2 Mechanical.

The provisions of this Code shall apply to the installation, alterations, repairs and replacement of mechanical systems, including equipment, appliances, fixtures, fittings and appurtenances, including ventilating, heating, cooling, air-conditioning and refrigeration systems, incinerators and other energy-related systems.

1.1.4.3 Plumbing.

The provisions of this Code shall apply to the installation, alteration, repair and replacement of plumbing systems, including equipment, appliances, fixtures, fittings and appurtenances, and where connected to a water or sewage
system and all aspects of a medical gas system. The provisions of this Code shall apply to private sewage disposal systems.

1.1.4.4 Property maintenance.

The provisions of this Code shall apply to existing structures and premises; equipment and facilities; light, ventilation, space heating, sanitation, life and fire safety hazards; responsibilities of owners, operators and occupants; and occupancy of existing premises and structures.

1.1.4.5 Fire prevention.

The provisions of this Code shall apply to matters affecting or relating to structures, processes and premises from the hazard of fire and explosion arising from the storage, handling or use of structures, materials or devices; from conditions hazardous to life, property or public welfare in the occupancy of structures or premises; and from the construction, extension, repair, alteration or removal of fire suppression, automatic sprinkler systems and alarm systems or fire hazards in the structure or on the premises from occupancy or operation.

1.1.4.6 Energy.

The provisions of this Code shall apply to all matters governing the design and construction of buildings for energy efficiency.

1.1.4.7 Existing buildings.

The provisions of this Code shall apply to matters governing the repair, alteration, change of occupancy, addition to and relocation of existing buildings.

1.2 APPLICABILITY

1.2.1 General.

Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable. Where, in any specific case, different clauses of this Code specify different materials, methods of construction or other requirements, the most restrictive shall govern.

1.2.2 Application of references.

References to Part or clause numbers, or to provisions not specifically identified by number, shall be construed to refer to such part, clause or provision of this Code.

1.2.3 Referenced Codes and standards.

The Codes and standards referenced in this Code shall be considered to be part of the requirements of this Code to the prescribed extent of each such reference and as further regulated in Clauses 1.2.3.1 and 1.2.3.2.

1.2.3.1 Conflicts.

Where conflicts occur between provisions of this Code and referenced Codes and standards, the provisions of this Code shall apply.

1.2.3.2 Provisions in referenced Codes and standards.

Where the extent of the reference to a referenced Code or standard includes subject matter that is within the scope of this Code or those listed in Clause 1.1.4, the provisions of this Code as listed in Clause 1.1.4, as applicable, shall take precedence over the provisions in the referenced Code or standard.

1.2.4 Partial invalidity.

In the event that any part or provision of this Code is held to be illegal or void, this shall not have the effect of making void or illegal any of the other parts or provisions.

1.2.5 Existing structures.

The legal occupancy of any structure existing on the date of adoption of this Code shall be permitted to continue without change, except as otherwise specifically provided in this Code, or the Ghana Fire Code.

1.2.5.1 Buildings not previously occupied.

A building or portion of a building that has not been previously occupied or used for its intended purpose in existence at the time of its completion shall comply with the provisions of this Code as applicable, for new construction or with any current permit for such occupancy.
1.2.5.2 Buildings previously occupied.

The legal occupancy of any building existing on the date of adoption of this Code shall be permitted to continue without change, except as otherwise specifically provided in this Code, the Ghana Fire Code or as is deemed necessary by the Head of Works for the general safety and welfare of the occupants and the public.

ADMINISTRATION AND ENFORCEMENT

1.3 BUILDING SAFETY

1.3.1 Enforcement agency.

The Works Department of the Metropolitan, Municipal and District Assemblies (MMDAs) shall be in-charge of building safety and the officer in charge thereof shall be the Head of Works.

1.3.1.1 Appointment

The Head of Works shall be appointed by the Authority.

1.3.1.2 Organization

The Head of Works shall appoint such number of officers, technical assistants, inspectors and other employees as shall be necessary for the administration of the Code and as authorized by the Authority.

1.3.1.3 Delegation of Powers

The Head of Works may designate an employee or employees who shall exercise all the powers of the office during the temporary absence or disability of the Head of Works.

1.3.1.4 Qualification of Head of Works

The Head of Works shall be a licensable Engineer or Structural Engineer or Architect or Town Planner or Quantity Surveyor/Surveyor Valuer whose qualification shall not in any case be less than those prescribed in Appendix A.

1.3.1.5 In small local/district bodies having insufficient funds to appoint such officials with the above qualifications, two or more such bodies could join and have one qualified Head of Works.

1.3.1.6 Qualifications of Building Assistant Supervisor

No person shall be appointed as Building Assistant/Supervisor unless such a person has the qualifications prescribed in Appendix A for a licensed building Supervisor.

1.4 DUTIES AND POWERS OF HEAD OF WORKS

1.4.1 General.

The Head of Works is hereby authorized and directed to enforce the provisions of this Code. The Head of Works shall have the authority to render interpretations of this Code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in compliance with the intent and purpose of this Code. Such policies and procedures shall not have the effect of waiving requirements specifically provided for in this Code.

1.4.2 Applications and permits.

The Head of Works shall receive applications, review construction documents and issue permits for the erection, and alteration, demolition and moving of buildings and structures, inspect the premises for which such permits have been issued and enforce compliance with the provisions of this Code.

1.4.2.1 Determination of substantially improved or substantially damaged existing buildings and structures in flood hazard areas.

For applications for reconstruction, rehabilitation, repair, alteration, addition or other improvement of existing buildings or structures located in flood hazard areas, the Head of Works shall determine if the proposed work constitutes substantial improvement or repair of substantial damage. Where the Head of Works determines that the proposed work constitutes substantial improvement or repair of substantial damage, and where required by this Code.
1.4.3 Notices and orders.

The Head of Works shall issue necessary notices or orders to ensure compliance with this Code.

1.4.4 Inspections.

The Head of Works shall make the required inspections, or the Head of Works shall have the authority to accept reports of inspection by approved agencies or individuals. Reports of such inspections shall be in writing and be certified by a responsible officer of such approved agency or by the responsible individual. The Head of Works is authorized to engage such expert opinion as deemed necessary to report on unusual technical issues that arise, subject to the approval of the appointing authority.

1.4.5 Identification.

The Head of Works shall carry proper identification when inspecting structures or premises in the performance of duties under this Code.

1.4.6 Right of entry.

Where it is necessary to make an inspection to enforce the provisions of this Code, or where the Head of Works has reasonable cause to believe that there exists in a structure or on a premises a condition that is contrary to or in violation of this Code that makes the structure or premises unsafe, dangerous or hazardous, the Head of Works is authorized to enter the structure or premises at reasonable times to inspect or to perform the duties imposed by this Code, provided that if such structure or premises be occupied that credentials be presented to the occupant and entry requested. If such structure or premises is unoccupied, the Head of Works shall first make a reasonable effort to locate the owner or other person having charge or control of the structure or premises and request entry. If entry is refused, the Head of Works shall have recourse to the remedies provided by law to secure entry.

1.4.7 Department records.

The Head of Works shall keep official records of applications received, permits and certificates issued, fees collected, reports of inspections, and notices and orders issued. Such records shall be retained in the official records for the period required for retention of public records.

1.4.8 Liability.

The Head of Works, member of the board of appeals or employee charged with the enforcement of this Code, while acting for the jurisdiction in good faith and without malice in the discharge of the duties required by this Code or other pertinent law or ordinance, shall not thereby be civilly or criminally rendered liable personally and is hereby relieved from personal liability for any damage accruing to persons or property as a result of any act or by reason of an act or omission in the discharge of official duties.

1.4.8.1 Legal defense.

Any suit or criminal complaint instituted against an officer or employee because of an act performed by that officer or employee in the lawful discharge of duties and under the provisions of this Code shall be defended by legal representatives of the jurisdiction until the final termination of the proceedings. The Head of Works or any subordinate shall not be liable for cost in any action, suit or proceeding that is instituted in pursuance of the provisions of this Code.

1.4.9 Approved materials and equipment.

Materials, equipment and devices approved by the Head of Works shall be constructed and installed in accordance with such approval.

1.4.9.1 Used materials and equipment.

Materials that are reused shall comply with the requirements of this Code for new materials. Used equipment and devices shall not be reused unless approved by the Head of Works.

1.4.10 Modifications.

Where there are practical difficulties involved in carrying out the provisions of this Code, the Head of Works shall have the authority to grant modifications for individual cases, upon application of the owner or the owner’s authorized agent, provided that the Head of Works shall first find that special individual reason makes the strict letter of this Code impractical, the modification is in compliance
with the intent and purpose of this Code and that such modification does not lessen health, accessibility, life and fire safety or structural requirements. The details of action granting modifications shall be recorded and entered in the files of the department of building safety.

1.4.10.1 Flood hazard areas.

The Head of Works shall not grant modifications to any provision required in flood hazard areas as established by this Code unless a determination has been made that:

1. A showing of good and sufficient cause that the unique characteristics of the size, configuration or topography of the site render the elevation standards of this Code inappropriate.

2. A determination that failure to grant the variance would result in exceptional hardship by rendering the plot undevelopable.

3. A determination that the granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, cause fraud on or victimization of the public, or conflict with existing Code or legislation.

4. A determination that the variance is the minimum necessary to afford relief, considering the flood hazard.

5. Submission to the applicant of written notice specifying the difference between the design flood elevation and the elevation to which the building is to be built, stating that the cost of flood insurance will be commensurate with the increased risk resulting from the reduced floor elevation, and stating that construction below the design flood elevation increases risks to life and property.

1.4.11 Alternative materials, design and methods of construction and equipment.

The provisions of this Code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this Code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the Head of Works finds that the proposed design is satisfactory and complies with the intent of the provisions of this Code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this Code in quality, strength, effectiveness, fire resistance, durability and safety. Where the alternative material, design or method of construction is not approved, the Head of Works shall respond in writing, stating the reasons why the alternative was not approved.

1.4.11.1 Research reports.

Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this Code, shall consist of valid research reports from approved sources.

1.4.11.2 Tests.

Whenever there is insufficient evidence of compliance with the provisions of this Code, or evidence that a material or method does not conform to the requirements of this Code, or in order to substantiate claims for alternative materials or methods, the Head of Works shall have the authority to require tests as evidence of compliance to be made without expense to the jurisdiction. Test methods shall be as specified in this Code or by other recognized test standards. In the absence of recognized and accepted test methods, the Head of Works shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the Head of Works for the period required for retention of public records.

1.5 VALIDITY

1.5.1 Partial Invalidity

In the event any part or provision of this Code is held to be illegal or void, this shall not have the effect of making void or illegal any of the other parts or provisions thereof, which may or shall be determined to be legal, and it shall be presumed that the Code would have been passed without such illegal or invalid parts or provisions.
1.5.2 Segregation of Invalid Provisions

Any invalid part of the Code shall be segregated from the remainder of the Code by the court holding such part invalid, and the remainder shall remain effective.

1.5.3 Decisions involving Existing Buildings

The invalidity of any provision in any clause of the Code as applied to existing buildings and structures shall not be held to affect the validity of such clause in its application to buildings hereafter erected.

1.6 PERMITS

1.6.1 Required Permits.

Any owner or owner’s authorized agent who intends to construct, enlarge, alter, repair, move, demolish or change the occupancy of a building or structure, or to erect, install, enlarge, alter, repair, remove, convert or replace any electrical, gas, mechanical or plumbing system, the installation of which is regulated by this Code, or to cause any such work to be performed, shall first make application to the Local Authority (MMDAs) to obtain the required permit.

1.6.1.1 An occupancy permit is required:

(a) to allow the occupancy of a building or part thereof;
(b) when occupancy of a building or part thereof is changed.

1.6.1.2 Annual permit records.

The person to whom an annual permit is issued shall keep a detailed record of alterations made under such annual permit. The Head of Works shall have access to such records at all times or such records shall be filed with the Head of Works as designated.

1.6.2 Work exempt from permit.

Exemptions from permit requirements of this Code shall not be deemed to grant authorization for any work to be done in any manner in violation of the provisions of this Code or legislation. Permits shall not be required for the following:

Building:

1. One-storey detached accessory structures used as tool and storage sheds, playhouses and similar uses, provided that the floor area is not greater than $11 \text{m}^2$ (120 square feet).

2. Sidewalks and driveways not more than 762 mm (30 inches) above adjacent grade, and not over any basement or storey below and are not part of an accessible route.

3. Painting, papering, tiling, carpeting, cabinets, counter tops and similar finish work for dwelling units.

4. Prefabricated swimming pools accessory to a Group R-3 occupancy that are less than 610 mm (24 inches) deep, are not greater than 18 925 L (5,000 gallons) and are installed entirely above ground.

5. Shade cloth structures constructed for nursery or agricultural purposes, not including service systems.

6. Swings and other playground equipment accessory to detached one- and two-family dwellings.

7. Window awnings in Group R-3 and U occupancies, supported by an exterior wall that do not project more than 1372 mm (54 inches) from the exterior wall and do not require additional support.

8. Nonfixed and movable fixtures, cases, racks, counters and partitions not over 5 feet 1753 mm (9 inches) in height.

1.6.3 The operational construction of the Government, whether temporary or permanent,
which is necessary for the operation, maintenance, development or execution of any of the following services may be exempt from the point of view of this Code:

(a) Railways;
(b) National highways;
(c) National waterways;
(d) Major ports;
(e) Airways and aerodromes;
(f) Posts, telephones, wireless, broadcasting and other like forms of communications;
(g) Regional grid for electricity;
(h) Any other service which the Government may, if it is of the opinion that the operation, maintenance, development or execution of such service is essential to the life of the community, by notification, declare to be a service for the purpose of this clause.
(i) In relation to special constructions exemptions, Buildings that do not require construction permits shall need planning permit.

Electrical:

1. Repairs and maintenance: Minor repair work, including the replacement of lamps or the connection of approved portable electrical equipment to approved permanently installed receptacles.

2. Temporary testing systems: A permit shall not be required for the installation of any temporary system required for the testing or servicing of electrical equipment or apparatus.

Gas:

1. Replacement of any minor part that does not alter approval of equipment or make such equipment unsafe.

Mechanical:

1. Portable ventilation equipment.

2. Portable cooling unit.

3. Steam, hot or chilled water piping within any heating or cooling equipment regulated by this Code.

4. Replacement of any part that does not alter its approval or make it unsafe.

5. Portable evapourative cooler.

6. Self-contained refrigeration system containing 4.54 kg (10 pounds) or less of refrigerant and actuated by motors of 0.75 kW (1 horsepower) or less.

Plumbing:

1. The stopping of leaks in drains, water, soil, waste or vent pipe, provided, however, that if any concealed trap, drain pipe, water, soil, waste or vent pipe becomes defective and it becomes necessary to remove and replace the same with new material, such work shall be considered as new work and a permit shall be obtained and inspection made as provided in this Code.

2. The clearing of stoppages or the repairing of leaks in pipes, valves or fixtures and the removal and reinstallation of water closets, provided that such repairs do not involve or require the replacement or rearrangement of valves, pipes or fixtures.

1.6.3.1 Emergency repairs.
Where equipment replacements and repairs must be performed in an emergency situation, the permit application shall be submitted within the next working business day to the Head of Works.

1.6.3.2 Public service agencies.
A permit shall not be required for the installation, alteration or repair of generation, transmission, distribution or metering or other related equipment that is under the ownership
and control of public service agencies by established right.

1.6.3.3 Application for permit.
To obtain a permit, the applicant shall first file an application therefore in writing on a form furnished by the department of building safety for that purpose. Such application shall:

1. Identify and describe the work to be covered by the permit for which application is made.
2. Describe the land on which the proposed work is to be done by legal description, street address or similar description that will readily identify and definitely locate the proposed building or work.
3. Indicate the use and occupancy for which the proposed work is intended.
4. Be accompanied by construction documents and other information as required in Clause 1.9
5. State the valuation of the proposed work.
6. Be signed by the applicant, or the applicant’s authorized agent.
7. Give such other data and information as required by the Head of Works.

1.6.3.4 Action on application.
The Head of Works shall examine or cause to be examined applications for permits and amendments thereto within a reasonable time after filing. If the application or the construction documents do not conform to the requirements of pertinent of this Code the Head of Works shall reject such application in writing, stating the reasons therefore. If the Head of Works is satisfied that the proposed work conforms to the requirements of this Code and legislation applicable thereto, the Head of Works shall issue a permit therefore as soon as practicable.

1.6.3.5 Time limitation of application.
An application for a permit for any proposed work shall be deemed to have been abandoned 180 days after the date of filing, unless such application has been pursued in good faith or a permit has been issued; except that the Head of Works is authorized to grant one or more extensions of time for additional periods not exceeding 90 days each. The extension shall be requested in writing and justifiable cause demonstrated.

1.6.4 Validity of permit.
The issuance or granting of a permit shall not be construed to be a permit for, or an approval of, any violation of any of the provisions of this Code or of any other ordinance of the jurisdiction. Permits presuming to give authority to violate or cancel the provisions of this Code or other ordinances of the jurisdiction shall not be valid. The issuance of a permit based on construction documents and other data shall not prevent the Head of Works from requiring the correction of errors in the construction documents and other data. The Head of Works is authorized to prevent occupancy or use of a structure where in violation of this Code or of any other ordinances of this jurisdiction.

1.6.5 Expiration.
Every permit issued shall become invalid unless the work on the site authorized by such permit is commenced within 180 days after its issuance, or if the work authorized on the site by such permit is suspended or abandoned for a period of 180 days after the time the work is commenced. The Head of Works is authorized to grant, in writing, one or more extensions of time, for periods not more than 180 days each. The extension shall be requested in writing and justifiable cause demonstrated.

1.6.6 Suspension or revocation.
The Head of Works is authorized to suspend or revoke a permit issued under the provisions of this Code wherever the permit is issued in error or on the basis of incorrect, inaccurate or incomplete information, or in violation of any ordinance or regulation or any of the provisions of this Code.

1.6.7 Placement of permit.
The building permit or copy shall be kept on the site of the work until the completion of the project.

1.6.8 Permit for a Temporary Building
Notwithstanding anything contained elsewhere in this Code, a permit for a temporary building
may be issued by the authority having jurisdiction, authorizing for a limited time only the erection and existence of a building or part thereof for an occupancy which because of its nature will exist for a short time under circumstances which warrant only selective compliance with the provisions of this Code. Refer to clause 1.5.2 for the exception to this requirement.

1.6.8.1 A permit for a temporary building shall state the date after which and the conditions under which the permit is no longer valid.

1.6.8.2 A permit for a temporary building may be extended provided permission in writing is granted by the authority having jurisdiction.

1.6.8.3 A permit for a temporary building shall be posted on the building.

1.7 DEMOLITION OF BUILDING

Before a building is demolished, the owner shall notify all utilities having service connections within the building, such as water, electric, gas sewer and other connections. A permit to demolish a building shall not be issued until a release is obtained from the utilities stating that their respective service connections and appurtenant equipment such as meters and regulators have been removed or sealed and plugged in a safe manner.

1.8 FLOOR AND ROOF DESIGN LOADS

1.8.1 Live loads posted.

In commercial or industrial buildings, for each floor or portion thereof designed for live loads exceeding 2.40 kN/m² (50 psf), such design live loads shall be conspicuously posted by the owner or the owner’s authorized agent in that part of each storey in which they apply, using durable signs. It shall be unlawful to remove or deface such notices.

1.8.2 Issuance of certificate of occupancy.

A certificate of occupancy required by Clause 1.13 shall not be issued until the floor load signs, required by this Code, have been installed.

1.8.3 Restrictions on loading.

It shall be unlawful to place, or cause or permit to be placed, on any floor or roof of a building, structure or portion thereof, a load greater than is permitted by this Code.

1.9 SUBMISSION DOCUMENTS

1.9.1 General.

Submission documents consisting of construction documents, statement of special inspections, geotechnical report and other data shall be submitted with the required sets with each permit application. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the Head of Works is authorized to require additional construction documents to be prepared by a registered design professional.

1.9.2 Construction documents.

Construction documents shall be in accordance with Clauses 1.9.2.1 through 1.9.2.8.

1.9.2.1 Information on construction documents.

Construction documents shall be dimensioned and drawn on suitable material. Electronic media documents are permitted to be submitted where approved by the Head of Works. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this Code and relevant legislation, rules and regulations, as determined by the Head of Works.

1.9.2.1.1 Additional Information accompanying Notice

Except otherwise allowed by the authority having jurisdiction every application shall:

(a) identify and describe in detail the work and occupancy to be covered by the permit for which application is made;

(b) describe land on which the work is to be done, by a description that
will readily identify and locate the building/plot;

(c) include plans and specifications, unless otherwise approved by the authority having jurisdiction, and show the occupancy of all parts of the building;

(d) state the cost of the proposed work, and be accompanied by the required fee;

(e) state the names, addresses and telephone numbers of the owner, architect, engineer or other designer and constructor;

(f) in the case of building plans for multi-storey/special buildings (that is, buildings that are more than 15m in height and for special buildings like educational, assembly, institutional, industrial, storage and hazardous and mixed occupancies having area more than 500m²), require the following additional information, as applicable;

(i) access to fire appliances/vehicles with details of vehicular turning circle and clear motorable accessway around the building;
(ii) width of main and alternative staircases along with balcony approach, corridor, ventilated lobby approach;
(iii) location and details of lift enclosures;
(iv) location and size of fire lift;
(v) smoke stop lobby/door, where provided;
(vi) refuse chutes, refuse chamber, service duct, etc;
(vii) vehicular parking spaces;
(viii) refuse area, if any;
(ix) details of building services.

1.9.2.2 Fire protection system shop drawings.

Shop drawings for the fire protection system(s) shall be submitted to indicate conformance to this Code and the construction documents and shall be approved prior to the start of system installation. Shop drawings shall contain all information as required by the referenced installation standards in Part 9.

1.9.2.3 Means of escape.

The construction documents shall show in sufficient detail the location, construction, size and character of all portions of the means of escape including the path of the exit discharge to the public way in compliance with the provisions of this Code. In other than occupancies in Groups R-2, R-3, and I-1, the construction documents shall designate the number of occupants to be accommodated on every floor, and in all rooms and spaces.

1.9.2.4 Exterior wall envelope.

Construction documents for all buildings shall describe the exterior wall envelope in sufficient detail to determine compliance with this Code. The construction documents shall provide details of the exterior wall envelope as required, including flashing, interclauses with dissimilar materials, corners, end details, control joints, interclauses at roof, eaves or parapets, means of drainage, water-resistive membrane and details around openings. The construction documents shall include manufacturer’s installation instructions that provide supporting documentation that the proposed penetration and opening details described in the construction documents maintain the weather resistance of the exterior wall envelope. The supporting documentation shall fully describe the exterior wall system that was tested, where applicable, as well as the test procedure used.

1.9.2.5 Exterior balconies and elevated walking surfaces.

Where balconies or other elevated walking surfaces are exposed to water from direct or blowing rain, snow, or irrigation, and the structural framing is protected by an impervious moisture barrier, the construction documents shall include details for all elements of the impervious moisture barrier system. The construction documents shall include manufacturer’s installation instructions.

1.9.2.6 Site plan.

The construction documents submitted with the application for permit shall be accompanied by a site plan showing to scale the size and
location of new construction and existing structures on the site, distances from plot lines, the established street grades and the proposed finished grades and, as applicable, flood hazard areas, floodways, and design flood elevations; and it shall be drawn in accordance with an accurate boundary line survey. In the case of demolition, the site plan shall show construction to be demolished and the location and size of existing structures and construction that are to remain on the site or plot. The Head of Works is authorized to waive or modify the requirement for a site plan where the application for permit is for alteration or repair or where otherwise warranted.

1.9.2.6.1 Design flood elevations.
Where design flood elevations are not specified, they shall be established in accordance with this Code.

1.9.2.7 Structural information.
The construction documents shall provide the information specified in this Code.

1.9.2.8 Relocatable buildings.
Construction documents for relocatable buildings shall comply with this Code.

1.9.3 Examination of documents.
The Head of Works shall examine or cause to be examined the accompanying Submission documents and shall ascertain by such examinations whether the construction indicated and described is in accordance with the requirements of this Code or legislation.

1.9.3.1 Approval of construction documents.
When the Head of Works issues a permit, the construction documents shall be approved, in writing or by stamp, as “Reviewed for Code Compliance.” One set of construction documents so reviewed shall be retained by the Head of Works. The other set shall be returned to the applicant, shall be kept at the site of work and shall be open to inspection by the Head of Works or a duly authorized representative.

1.9.3.2 Previous approvals.
This Code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this Code and has not been abandoned.

1.9.3.3 Phased approval.
The Head of Works is authorized to issue a permit for the construction of foundations or any other part of a building or structure before the construction documents for the whole building or structure have been submitted, provided that adequate information and detailed statements have been filed complying with pertinent requirements of this Code. The holder of such permit for the foundation or other parts of a building or structure shall proceed at the holder’s own risk with the building operation and without assurance that a permit for the entire structure will be granted.

1.9.3.4 Design professional in responsible charge.
Where it is required that documents be prepared by a registered design professional, the Head of Works shall be authorized to require the owner or the owner’s authorized agent to engage and designate on the building permit application a registered design professional who shall act as the registered design professional in responsible charge. If the circumstances require, the owner or the owner’s authorized agent shall designate a substitute registered design professional in responsible charge who shall perform the duties required of the original registered design professional in responsible charge. The Head of Works shall be notified in writing by the owner or the owner’s authorized agent if the registered design professional in responsible charge is changed or is unable to continue to perform the duties.

The registered design professional in responsible charge shall be responsible for reviewing and coordinating Submission documents prepared by others, including phased and deferred Submission items, for compatibility with the design of the building.
1.9.3.4.1 Deferred Submissions.

Deferral of any Submission items shall have the prior approval of the Head of Works. The registered design professional in responsible charge shall list the deferred Submissions on the construction documents for review by the Head of Works.

Documents for deferred Submission items shall be submitted to the registered design professional in responsible charge who shall review them and forward them to the Head of Works with a notation indicating that the deferred Submission documents have been reviewed and found to be in general conformance to the design of the building. The deferred Submission items shall not be installed until the deferred Submission documents have been approved by the Head of Works.

1.9.4 Amended construction documents.

Work shall be installed in accordance with the approved construction documents, and any changes made during construction that are not in compliance with the approved construction documents shall be resubmitted for approval as an amended set of construction documents.

1.9.5 Retention of construction documents.

One set of approved construction documents shall be retained by the Head of Works for a period of not less than 180 days from date of completion of the permitted work, or as required by this Code.

1.10 TEMPORARY STRUCTURES AND USES

1.10.1 General.

The Head of Works is authorized to issue a permit for temporary structures and temporary uses. Such permits shall be limited as to time of service, but shall not be permitted for more than 180 days. The Head of Works is authorized to grant extensions for demonstrated cause.

1.10.2 Conformance.

Temporary structures and uses shall comply with the requirements in this Code.

1.10.3 Temporary power.

The Head of Works is authorized to give permission to temporarily supply and use power in part of an electric installation before such installation has been fully completed and the final certificate of completion has been issued. The part covered by the temporary certificate shall comply with the requirements specified for temporary lighting, heat or power in Ghana Wiring Code.

1.10.4 Termination of approval.

The Head of Works is authorized to terminate such permit for a temporary structure or use and to order the temporary structure or use to be discontinued.

1.11 FEES

1.11.1 Payment of fees.

A permit shall not be valid until the fees prescribed by law have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.

1.11.2 Schedule of permit fees.

On buildings, structures, electrical, gas, mechanical, and plumbing systems or alterations requiring a permit, a fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.

1.11.3 Building permit valuations.

The applicant for a permit shall provide an estimated permit value at time of application. Permit valuations shall include total value of work, including materials and labor, for which the permit is being issued, such as electrical, gas, mechanical, plumbing equipment and permanent systems. If, in the opinion of the Head of Works, the valuation is underestimated on the application, the permit shall be denied, unless the applicant can show detailed estimates to meet the approval of the Head of Works. Final building permit valuation shall be set by the Head of Works.
1.11.4 Work commencing before permit issuance.
Any person who commences any work on a building, structure, electrical, gas, mechanical or plumbing system before obtaining the necessary permits shall be subject to a fee established by the Head of Works that shall be in addition to the required permit fees.

1.11.5 Related fees.
The payment of the fee for the construction, alteration, removal or demolition for work done in connection to or concurrently with the work authorized by a building permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.

1.11.6 Refunds.
The Head of Works is authorized to establish a refund policy.

1.12 INSPECTIONS
1.12.1 General.
Construction or work for which a permit is required shall be subject to inspection by the Head of Works and such construction or work shall remain visible and able to be accessed for inspection purposes until approved. Approval as a result of an inspection shall not be construed to be an approval of a violation of the provisions of this Code or of other ordinances of the jurisdiction. Inspections presuming to give authority to violate or cancel the provisions of this Code or of other ordinances of the jurisdiction shall not be valid. It shall be the duty of the owner or the owner's authorized agent to cause the work to remain visible and able to be accessed for inspection purposes. Neither the Head of Works nor the jurisdiction shall be liable for expense entailed in the removal or replacement of any material required to allow inspection.

1.12.2 Preliminary inspection.
Before issuing a permit, the Head of Works is authorized to examine or cause to be examined buildings, structures and sites for which an application has been filed.

1.12.3 Required inspections.
The Head of Works, upon notification, shall make the inspections set forth in Clauses 1.12.3.1 through 1.12.3.11.

1.12.3.1 Footing and foundation inspection.
Footing and foundation inspections shall be made after excavations for footings are complete and any required reinforcing steel is in place. For concrete foundations, any required forms shall be in place prior to inspection. Materials for the foundation shall be on the job, except where concrete is ready mixed in accordance with ASTM C94, the concrete need not be on the job.

1.12.3.2 Concrete slab and under-floor inspection.
Concrete slab and under-floor inspections shall be made after in-slab or under-floor reinforcing steel and building service equipment, conduit, piping accessories and other ancillary equipment items are in place, but before any concrete is placed or floor sheathing installed, including the subfloor.

1.12.3.3 Lowest floor elevation.
In flood hazard areas, upon placement of the lowest floor, including the basement, and prior to further vertical construction, the elevation certification required in this Code shall be submitted to the Head of Works.

1.12.3.4 Frame inspection.
Framing inspections shall be made after the roof deck or sheathing, all framing, fire-blocking and bracing are in place and pipes, chimneys and vents to be concealed are complete and the rough electrical, plumbing, heating wires, pipes and ducts are approved.
1.12.3.5 Lath, gypsum board and gypsum panel product inspection.

Lath, gypsum board and gypsum panel product inspections shall be made after lathing, gypsum board and gypsum panel products, interior and exterior, are in place, but before any plastering is applied or gypsum board and gypsum panel product joints and fasteners are taped and finished.

**Exception:** Gypsum board and gypsum panel products that are not part of a fire-resistance-rated assembly or a shear assembly.

1.12.3.6 Weather-exposed balcony and walking surface waterproofing.

Where balconies or other elevated walking surfaces are exposed to water from direct or blowing rain, snow or irrigation, and the structural framing is protected by an impervious moisture barrier, all elements of the impervious moisture barrier system shall not be concealed until inspected and approved.

**Exception:** Where special inspections are provided in accordance with this Code.

1.12.3.7 Fire- and smoke-resistant penetrations.

Protection of joints and penetrations in fire-resistance-rated assemblies, smoke barriers and smoke partitions shall not be concealed from view until inspected and approved.

1.12.3.8 Energy efficiency inspections.

Inspections shall be made to determine compliance with Part 14 and shall include, but not be limited to, inspections for: envelope insulation R- and U-values, fenestration U-value, duct system R-value, and HVAC and water-heating equipment efficiency.

1.12.3.9 Other inspections.

In addition to the inspections specified in Clauses 1.12.3.1 through 1.12.3.8, the Head of Works is authorized to make or require other inspections of any construction work to ascertain compliance with the provisions of this Code that are enforced by the department of building safety.

1.12.3.10 Special inspections.

For special inspections, see Part 19.

1.12.3.11 Final inspection.

The final inspection shall be made after all work required by the building permit is completed.

1.12.3.11.1 Flood hazard documentation.

If located in a flood hazard area, documentation of the elevation of the lowest floor as required in this Code shall be submitted to the Head of Works prior to the final inspection.

1.12.4 Inspection agencies.

The Head of Works is authorized to accept reports of approved inspection agencies, provided that such agencies satisfy the requirements as to qualifications and reliability.

1.12.5 Inspection requests.

It shall be the duty of the holder of the building permit or their duly authorized agent to notify the Head of Works when work is ready for inspection. It shall be the duty of the permit holder to provide access to and means for inspections of such work that are required by this Code.

1.12.6 Approval required.

Work shall not be done beyond the point indicated in each successive inspection without first obtaining the approval of the Head of Works. The Head of Works, upon notification, shall make the requested inspections and shall either indicate the portion of the construction that is satisfactory as completed, or notify the permit holder or his or her agent wherein the same fails to comply with this Code. Any portions that do not comply shall be corrected and such portion shall not be covered or concealed until authorized by the Head of Works.
1.13 CERTIFICATE OF OCCUPANCY

1.13.1 Change of occupancy.

A building or structure shall not be used or occupied, and a change of occupancy of a building or structure or portion thereof shall not be made, until the Head of Works has issued a certificate of occupancy therefore as provided herein. Issuance of a certificate of occupancy shall not be construed as an approval of a violation of the provisions of this Code or legislation.

Exception: Certificates of occupancy are not required for work exempt from permits in accordance with this Code.

1.13.2 Certificate issued.

After the Head of Works inspects the building or structure and does not find violations of the provisions of this Code that are enforced by the department of building safety, the Head of Works shall issue a certificate of occupancy that contains the following:

1. The building permit number.
2. The address of the structure.
3. The name and address of the owner or the owner’s authorized agent.
4. A description of that portion of the structure for which the certificate is issued.
5. A statement that the described portion of the structure has been inspected for compliance with the requirements of this Code for the occupancy and division of occupancy and the use for which the proposed occupancy is classified.
6. The name of the Head of Works.
7. The edition of the Code under which the permit was issued.
8. The use and occupancy, in accordance with the provisions of Part 3.
9. The type of construction as defined in Part 7.
10. The design occupant load.
11. If an automatic sprinkler system is provided, whether the sprinkler system is required.
12. Any special stipulations and conditions of the building permit.

1.13.3 Temporary occupancy.

The Head of Works is authorized to issue a temporary certificate of occupancy before the completion of the entire work covered by the permit, provided that such portion or portions shall be occupied safely. The Head of Works shall set a time period during which the temporary certificate of occupancy is valid.

1.13.4 Revocation.

The Head of Works is authorized to, in writing, suspend or revoke a certificate of occupancy or completion issued under the provisions of this Code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure or portion thereof is in violation of any ordinance or regulation or any of the provisions of this Code.

1.14 SERVICE UTILITIES

1.14.1 Connection of service utilities.

A person shall not make connections from a utility, source of energy, fuel or power to any building or system that is regulated by this Code for which a permit is required, until released by the Head of Works.

1.14.2 Temporary connection.

The Head of Works shall have the authority to authorize the temporary connection of the building or system to the utility, source of energy, fuel or power.

1.14.3 Authority to disconnect service utilities.

The Head of Works shall have the authority to authorize disconnection of utility service to the building, structure or system regulated by this Code and the referenced Codes and standards set forth in Clause 1.1.4 in case of emergency where necessary to eliminate an immediate hazard to life or property or where such utility
connection has been made without the approval required by Clause 1.14.1 or 1.14.2. The Head of Works shall notify the serving utility, and wherever possible the owner and occupant of the building, structure or service system of the decision to disconnect prior to taking such action. If not notified prior to disconnecting, the owner or occupant of the building, structure or service system shall be notified in writing, as soon as practical thereafter.

1.15 BOARD OF APPEALS

1.15.1 General.

In order to hear and decide appeals of orders, decisions or determinations made by the Head of Works relative to the application and interpretation of this Code, there shall be a board of appeals. The board of appeals shall be appointed by the applicable governing authority and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business.

1.15.2 Limitations on authority.

An application for appeal shall be based on a claim that the true intent of this Code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this Code do not fully apply or an equally good or better form of construction is proposed. The board shall not have authority to waive requirements of this Code.

1.15.3 Qualifications.

The board of appeals shall consist of members who are qualified by experience and training to pass on matters pertaining to building construction and are not employees of the jurisdiction.

1.15.4 The Board of Appeal shall consist of at least 7 members, each with a minimum of 15 years professional experience and good standing members of the Ghana Institute of Architects, Ghana Institute of Planners, Ghana Institution of Engineering and the Ghana Institution of Surveyors, plus other members from other government agencies (e.g. Ghana National Fire Service, Environmental Protection Agency, etc.)

1.16 VIOLATIONS

1.16.1 Unlawful acts.

It shall be unlawful for any person, firm or corporation to erect, construct, alter, extend, repair, move, remove, demolish or occupy any building, structure or equipment regulated by this Code, or cause same to be done, in conflict with or in violation of any of the provisions of this Code.

1.16.2 Notice of violation.

The Head of Works is authorized to serve a notice of violation or order on the person responsible for the erection, construction, alteration, extension, repair, moving, removal, demolition or occupancy of a building or structure in violation of the provisions of this Code, or in violation of a permit or certificate issued under the provisions of this Code. Such order shall direct the discontinuance of the illegal action or condition and the abatement of the violation.

1.16.3 Prosecution of violation.

If the notice of violation is not complied with promptly, the Head of Works is authorized to request the legal counsel of the jurisdiction to institute the appropriate proceeding at law or in equity to restrain, correct or abate such violation, or to require the removal or termination of the unlawful occupancy of the building or structure in violation of the provisions of this Code or of the order or direction made pursuant thereto.

1.16.4 Violation penalties.

Any person who violates a provision of this Code or fails to comply with any of the requirements thereof or who erects, constructs, alters or repairs a building or structure in violation of the approved construction documents or directive of the Head of Works, or of a permit or certificate issued under the provisions of this Code, shall be subject to penalties as prescribed by law.
1.17 STOP WORK ORDER

1.17.1 Authority.

Where the Head of Works finds any work regulated by this Code being performed in a manner either contrary to the provisions of this Code or dangerous or unsafe, the Head of Works is authorized to issue a stop work order.

1.17.2 Issuance.

The stop work order shall be in writing and shall be given to the owner of the property involved, the owner's authorized agent or the person performing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order and the conditions under which the cited work will be permitted to resume.

1.17.3 Unlawful continuance.

Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to penalties as prescribed by law.

1.18 UNSAFE STRUCTURES AND EQUIPMENT

1.18.1 Conditions.

Structures or existing equipment that are or hereafter become unsafe, insanitary or deficient because of inadequate means of escape facilities, inadequate light and ventilation, or that constitute a fire hazard, or are otherwise dangerous to human life or the public welfare, or that involve illegal or improper occupancy or inadequate maintenance, shall be deemed an unsafe condition. Unsafe structures shall be taken down and removed or made safe, as the Head of Works deems necessary and as provided for in this clause. A vacant structure that is not secured against entry shall be deemed unsafe.

1.18.2 Record.

The Head of Works shall cause a report to be filed on an unsafe condition. The report shall state the occupancy of the structure and the nature of the unsafe condition.

1.18.3 Notice.

If an unsafe condition is found, the Head of Works shall serve on the owner, agent or person in control of the structure, a written notice that describes the condition deemed unsafe and specifies the required repairs or improvements to be made to abate the unsafe condition, or that requires the unsafe structure to be demolished within a stipulated time. Such notice shall require the person thus notified to declare immediately to the Head of Works acceptance or rejection of the terms of the order.

1.18.4 Method of service.

Such notice shall be deemed properly served if a copy thereof is: delivered to the owner personally; sent by certified or registered mail addressed to the owner at the last known address with the return receipt requested; or delivered in any other manner as prescribed by local law. If the certified or registered letter is returned showing that the letter was not delivered, a copy thereof shall be posted in a conspicuous place in or about the structure affected by such notice. Service of such notice in the foregoing manner on the owner's agent or on the person responsible for the structure shall constitute service of notice on the owner.

1.18.5 Restoration.

Where the structure or equipment determined to be unsafe by the Head of Works is restored to a safe condition, to the extent that repairs, alterations or additions are made or a change of occupancy occurs during the restoration of the structure, such repairs, alterations, additions and change of occupancy shall comply with the requirements of the International Existing Building Code.
PART 2: DEFINITIONS

User notes:

About this part: Codes, by their very nature, are technical documents. Every word, term and punctuation mark can add to or change the meaning of a technical requirement. It is necessary to maintain a consensus on the specific meaning of each term contained in the Code. Part 2 performs this function by stating clearly what specific terms mean for the purpose of the Code.

2.1 GENERAL

2.1.1 Scope.

Unless otherwise expressly stated, the following words and terms shall, for the purposes of this Code, have the meanings shown in this part.

2.1.2 Interchangeability.

Words used in the present tense include the future; words stated in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural, the singular.

2.1.3 Terms defined in other Codes.

Where terms are not defined in this Code and are defined in the Ghana Fire Code such terms shall have the meanings ascribed to them as in those Codes.

2.1.4 Terms not defined.

Where terms are not defined through the methods authorized by this clause, such terms shall have ordinarily accepted meanings such as the context implies.

2.2 DEFINITIONS

24-HOUR BASIS. The actual time that a person is an occupant within a facility for the purpose of receiving care. It shall not include a facility that is open for 24 hours and is capable of providing care to someone visiting the facility during any segment of the 24 hours.

AAC MASONRY. Masonry made of autoclaved aerated concrete (AAC) units, manufactured without internal reinforcement and bonded together using thin- or thick-bed mortar.

ACCESS. The portion that provides the means or right to enter

ACCESSIBLE. A site, building, facility or portion thereof that complies with Part 12.

ACCESSIBLE MEANS OF ESCAPE. A continuous and unobstructed way of escape travel from any accessible point in a building or facility to a public way.

ACCESSIBLE ROUTE. A continuous, unobstructed path that complies with Part 12.

ACCESSIBLE UNIT. A dwelling unit or sleeping unit that complies with this Code and the provisions for Accessible units in GS 1119.

ACCREDITATION BODY. An approved, third-party organization that is independent of the grading and inspection agencies, and the timber mills, and that initially accredits and subsequently monitors, on a continuing basis, the competency and performance of a grading or inspection agency related to carrying out specific tasks.

ADDITION. An extension or increase in floor area, number of stories or height of a building or structure.

ADHERED MASONRY VENEER. Veneer secured and supported through the adhesion of an approved bonding material applied to an approved backing.

ADOBE CONSTRUCTION. Construction in which the exterior load-bearing and nonload-bearing walls and partitions are of unfired clay masonry units, and floors, roofs and interior framing are wholly or partly of wood or other approved materials.

Adobe, stabilized. Unfired clay masonry units to which admixtures, such as emulsified asphalt, are added during the manufacturing process to limit the units’ water absorption so as to increase their durability.

Adobe, unstabilized. Unfired clay masonry units that do not meet the definition of “Adobe, stabilized.”

AEROSOL CONTAINER. A metal can or plastic container up to a maximum size of 33.8 fluid ounces (1000 ml), or a glass bottle up to a maximum size of 4 fluid ounces (118 ml), designed and intended to dispense an aerosol.

AEROSOL PRODUCT. A combination of a container, a propellant and a material that is dispensed. Aerosol products shall be classified by means of the calculation of their chemical
heats of combustion and shall be designated Level 1, Level 2 or Level 3.

**Level 1 aerosol products.** Those with a total chemical heat of combustion that is less than or equal to 8,600 British thermal units per pound (Btu/lb) (20 kJ/g).

**Level 2 aerosol products.** Those with a total chemical heat of combustion that is greater than 8,600 Btu/lb (20 kJ/g), but less than or equal to 13,000 Btu/lb (30 kJ/g).

**Level 3 aerosol products.** Those with a total chemical heat of combustion that is greater than 13,000 Btu/lb (30 kJ/g).

**AGRICULTURAL BUILDING.** A structure designed and constructed to house farm implements, hay, grain, poultry, livestock or other horticultural products. This structure shall not be a place of human habitation or a place of employment where agricultural products are processed, treated or packaged, nor shall it be a place used by the public.

**AIR-IMPERMEABLE INSULATION.** An insulation having an air permeance equal to or less than 0.02 l/s × m2 at 75 pa pressure differential tested in accordance with ASTM E2178 or ASTM E283.

**AIR-INFLATED STRUCTURE.** A structure that uses air-pressurized membrane beams, arches or other elements to enclose space. Occupants of such a structure do not occupy the pressurized area used to support the structure.

**AIR-SUPPORTED STRUCTURE.** A structure wherein the shape of the structure is attained by air pressure and occupants of the structure are within the elevated pressure area. Air-supported structures are of two basic types:

- **Double skin.** Similar to a single skin, but with an attached liner that is separated from the outer skin and provides an airspace which serves for insulation, acoustic, aesthetic or similar purposes.

- **Single skin.** Where there is only the single outer skin and the air pressure is directly against that skin.

**AISLE.** An unenclosed exit access component that defines and provides a path of escape travel.

**AISLE ACCESSWAY.** That portion of an exit access that leads to an aisle.

**ALARM NOTIFICATION APPLIANCE.** A fire alarm system component such as a bell, horn, speaker, light or text display that provides audible, tactile or visible outputs, or any combination thereof.

**ALARM SIGNAL.** A signal indicating an emergency requiring immediate action, such as a signal indicative of fire.

**ALARM VERIFICATION FEATURE.** A feature of automatic fire detection and alarm systems to reduce unwanted alarms wherein smoke detectors report alarm conditions for a minimum period of time, or confirm alarm conditions within a given time period, after being automatically reset, in order to be accepted as a valid alarm-initiation signal.

**ALLOWABLE STRESS DESIGN.** A method of proportioning structural members, such that elastically computed stresses produced in the members by nominal loads do not exceed specified allowable stresses produced in the structure.

**ALTERNATION.** Any construction or renovation to an existing structure other than repair or addition.

**AMBULATORY CARE FACILITY.** Buildings or portions thereof used to provide medical, surgical, psychiatric, nursing or similar care on a less than 24-hour basis to persons who are rendered incapable of self-preservation by the services provided or staff has accepted responsibility for care recipients already incapable.

**ANCHOR BUILDING.** An exterior perimeter building of a group other than H having direct access to a covered or open mall building but having required means of escape independent of the mall.

**ANCHORED MASONRY FINISH.** Finish secured with approved mechanical fasteners to an approved backing.

**ANNULAR SPACE.** The opening around the penetrating item.

**ANNUNCIATOR.** A unit containing one or more indicator lamps, alphanumeric displays or other equivalent means in which each indication provides status information about a circuit, condition or location.

**APPROVED.** Acceptable to the Head of Works.

**APPROVED AGENCY.** An established and recognized agency that is regularly engaged in conducting tests, furnishing inspection services or furnishing product certification where such
agency has been approved by the Head of Works.

APPROVED FABRICATOR. An established and qualified person, firm or corporation approved by the Head of Works pursuant to Part 19 of this Code.

APPROVED SOURCE. An independent person, firm or corporation, approved by the Head of Works, who is competent and experienced in the application of engineering principles to materials, methods or systems analyses.

AREA, BUILDING. The area included within surrounding exterior walls, or exterior walls and fire walls, exclusive of vent shafts and courts. Areas of the building not provided with surrounding walls shall be included in the building area if such areas are included within the horizontal projection of the roof or floor above.

AREA OF REFUGE. An area where persons unable to use stairways can remain temporarily to await instructions or assistance during emergency evacuation.

AREA OF SPORT ACTIVITY. That portion of an indoor or outdoor space where the play or practice of a sport occurs.

AREAWAY. A subsurface space adjacent to a building open at the top or protected at the top by a grating or guard.

ATRIUM. An opening connecting two or more stories other than enclosed stairways, elevators, hoistways, escalators, plumbing, electrical, air-conditioning or other equipment, which is closed at the top and not defined as a mall. Stories, as used in this definition, do not include balconies within assembly groups or mezzanines that comply with this Code.

ATTIC. The space between the ceiling framing of the top storey and the underside of the roof.

AUDIBLE ALARM NOTIFICATION APPLIANCE. A notification appliance that alerts by the sense of hearing.

AUTOMATIC. As applied to fire protection devices, a device or system providing an emergency function without the necessity for human intervention and activated as a result of a predetermined temperature rise, rate of temperature rise or combustion products.

AUTOMATIC FIRE-EXTINGUISHING SYSTEM. An approved system of devices and equipment which automatically detects a fire and discharges an approved fire-extinguishing agent onto or in the area of a fire.

AUTOMATIC SMOKE DETECTION SYSTEM. A fire alarm system that has initiation devices that utilize smoke detectors for protection of an area such as a room or space with detectors to provide early warning of fire.

AUTOMATIC SPRINKLER SYSTEM. An automatic sprinkler system, for fire protection purposes, is an integrated system of underground and overhead piping designed in accordance with fire protection engineering standards.

AUTOMATIC WATER MIST SYSTEM. A system consisting of a water supply, a pressure source and a distribution piping system with attached nozzles, which, at or above a minimum operating pressure defined by its listing, discharges water in fine droplets meeting the requirements of Ghana Fire Code for the purpose of the control, suppression or extinguishment of a fire. Such systems include wet-pipe, dry-pipe and preaction types. The systems are designed as engineered, preengineered, local-application or total-flooding systems.

AVERAGE AMBIENT SOUND LEVEL. The root mean square, A-weighted sound pressure level measured over a 24-hour period, or the time any person is present, whichever time period is less.

AWNING. An architectural projection that provides weather protection, identity or decoration and is partially or wholly supported by the building to which it is attached. An awning is comprised of a lightweight frame structure over which a covering is attached.

BACKING. The wall or surface to which the veneer is secured.

BALANCED DOOR. A door equipped with double-pivoted hardware so designed as to cause a semicounterbalanced swing action when opening.

BALLAST. In roofing, ballast comes in the form of large stones or paver systems or light-weight interlocking paver systems and is used to provide uplift resistance for roofing systems that are not adhered or mechanically attached to the roof deck.

BARRICADE. A structure that consists of a combination of walls, floor and roof, which is designed to withstand the rapid release of
energy in an explosion and which is fully confined, partially vented or fully vented; or other effective method of shielding from explosive materials by a natural or artificial barrier.

Artificial barricade. An artificial mound or revetment a minimum thickness of 3 feet (914 mm).

Natural barricade. Natural features of the ground, such as hills, or timber of sufficient density that the surrounding exposures that require protection cannot be seen from the magazine or building containing explosives when the trees are bare of leaves.

BASEMENT (for flood loads). The portion of a building having its floor subgrade (below ground level) on all sides.

BASEMENT. A storey that is not a storey above grade plane

BEARING WALL STRUCTURE. A building or other structure in which vertical loads from floors and roofs are primarily supported by walls.

BED JOINT. The horizontal layer of mortar on which a masonry unit is laid.

BLEACHERS. Tiered seating supported on a dedicated structural system and two or more rows high and is not a building element.

BOARDING HOUSE. A building arranged or used for lodging for compensation, with or without meals, and not occupied as a single-family unit.

BRACED WALL LINE. A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing.

BRACED WALL PANEL. A full-height clause of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors. The panel’s length meets the requirements of its particular bracing method and contributes toward the total amount of bracing required along its braced wall line.

BREAKOUT. For revolving doors, a process whereby wings or door panels can be pushed open manually for means of escape travel.

BRICK. Calcium silicate (sand lime brick). A pressed and subsequently autoclaved unit that consists of sand and lime, with or without the inclusion of other materials.

Clay. A solid or hollow masonry unit of clay, usually formed into a rectangular prism, then burned or fired in a kiln; brick is a ceramic product.

Concrete. A concrete masonry unit made from Portland cement, water, and suitable aggregates, with or without the inclusion of other materials.

BUILDING. Any structure utilized or intended for supporting or sheltering any occupancy.

BUILDING ELEMENT. A fundamental component of building construction, listed in Table 601, which may or may not be of fire-resistance-rated construction and is constructed of materials based on the building type of construction.

BUILDING-INTEGRATED PHOTOVOLTAIC (BIPV) PRODUCT. A building product that incorporates photovoltaic modules and functions as a component of the building envelope

BUILDING-INTEGRATED PHOTOVOLTAIC ROOF PANEL (BIPV ROOF PANEL). A photovoltaic panel that functions as a component of the building envelope.

BUILDING LINE. The line established by law, beyond which a building shall not extend, except as specifically provided by law.

HEAD OF WORKS. The officer or other designated authority charged with the administration and enforcement of this Code, or a duly authorized representative.

BUILT-UP ROOF COVERING. Two or more layers of felt cemented together and surfaced with a cap sheet, mineral aggregate, smooth coating or similar surfacing material.

CABLE-RESTRAINED, AIR-SUPPORTED STRUCTURE. A structure in which the uplift is resisted by cables or webbings which are anchored to either foundations or dead men. Reinforcing cable or webbing is attached by various methods to the membrane or is an integral part of the membrane. This is not a cable-supported structure.

CANOPY. A permanent structure or architectural projection of rigid construction over which a covering is attached that provides weather protection, identity or decoration. A canopy is permitted to be structurally
independent or supported by attachment to a building on one or more sides.

**CAPACITOR ENERGY STORAGE SYSTEM.** A stationary, rechargeable energy storage system consisting of capacitors, chargers, controls and associated electrical equipment designed to provide electrical power to a building or facility. The system is typically used to provide standby or emergency power, an uninterruptable power supply, load shedding, load sharing or similar capabilities.

**Preengineered capacitor energy storage system.** A capacitor energy storage system consisting of capacitors, an energy management system, components and modules that are produced in a factory, designed to constitute the system when assembled and shipped to the job site for assembly.

**Prepackaged capacitor energy storage system.** A capacitor energy storage system consisting of capacitors, an energy management system, components and modules that is factory assembled and then shipped as a complete unit for installation at the job site.

**CARBON DIOXIDE EXTINGUISHING SYSTEMS.** A system supplying carbon dioxide (CO₂) from a pressurized vessel through fixed pipes and nozzles. The system includes a manual- or automatic-actuating mechanism.

**CARBON MONOXIDE ALARM.** A single- or multiple-station alarm intended to detect carbon monoxide gas and alert occupants by a distinct audible signal. It incorporates a sensor, control components and an alarm notification appliance in a single unit.

**CARBON MONOXIDE DETECTOR.** A device with an integral sensor to detect carbon monoxide gas and transmit an alarm signal to a connected alarm control unit.

**CARE SUITE.** In Group I-2 occupancies, a group of treatment rooms, care recipient sleeping rooms and the support rooms or spaces and circulation space within the suite where staff are in attendance for supervision of all care recipients within the suite, and the suite is in compliance with the requirements of this Code.

**CAST STONE.** A building stone manufactured from Portland cement concrete precast and used as a trim, veneer or facing on or in buildings or structures.

**CEILING LIMIT.** The maximum concentration of an airborne contaminant to which one may be exposed.

**CEILING RADIATION DAMPER.** A listed device installed in a ceiling membrane of a fire-resistance-rated floor/ceiling or roof/ceiling assembly to limit automatically the radiative heat transfer through an air inlet/outlet opening. Ceiling radiation dampers include air terminal units, ceiling dampers and ceiling air diffusers.

**CELL (Group I-3 occupancy).** A room within a housing unit in a detention or correctional facility used to confine inmates or prisoners.

**CELL (masonry).** A void space having a gross cross-clause area greater than 11/2 square inches (967 mm²).

**CELL TIER.** Levels of cells vertically stacked above one another within a housing unit.

**CEMENT PLASTER.** A mixture of Portland or blended cement, Portland cement or blended cement and hydrated lime, masonry cement or plastic cement and aggregate and other approved materials as specified in this Code.

**CERAMIC FIBER BLANKET.** A high-temperature mineral wool insulation material made of alumina-silica ceramic or calcium magnesium silicate soluble fibers and weighing 4 to 10 pounds per cubic foot (pcf) (64 to 160 kg/m³).

**CERTIFICATE OF COMPLIANCE.** A certificate stating that materials and products meet specified standards or that work was done in compliance with approved construction documents.

**CHANGE OF OCCUPANCY.** A change in the use of a building or a portion a building which results in one of the following:

1. A change of occupancy classification.
2. A change from one group to another group within an occupancy classification.
3. Any change in use within a group for which there is a change in application of the requirements of this Code.

**CHILDREN’S PLAY STRUCTURE.** A structure composed of one or more components, where the user enters a play environment.
CHIMNEY. A primarily vertical structure containing one or more flues, for the purpose of carrying gaseous products of combustion and air from a fuel-burning appliance to the outdoor atmosphere.

Factory-built chimney. A listed and labeled chimney composed of factory-made components, assembled in the field in accordance with manufacturer's instructions and the conditions of the listing.

Masonry chimney. A field-constructed chimney composed of solid masonry units, bricks, stones, or concrete.

Metal chimney. A field-constructed chimney of metal.

CIRCULATION PATH. An exterior or interior way of passage from one place to another for pedestrians.

CLEAN AGENT. Electrically nonconducting, volatile or gaseous fire extinguishant that does not leave a residue upon vapourisation.

CLIMATE ZONE. A geographical region that has been assigned climatic criteria as specified in Parts 3CE and 3RE of the International Energy Conservation Code.

CLINIC, OUTPATIENT. Buildings or portions thereof used to provide medical care on less than a 24-hour basis to persons who are not rendered incapable of self-preservation by the services provided.

CLOSED SYSTEM. The use of a solid or liquid hazardous material involving a closed vessel or system that remains closed during normal operations where vapours emitted by the product are not liberated outside of the vessel or system and the product is not exposed to the atmosphere during normal operations; and all uses of compressed gases. Examples of closed systems for solids and liquids include product conveyed through a piping system into a closed vessel, system or piece of equipment.

COLLAR JOINT. Vertical longitudinal space between Wythes of masonry or between masonry Wythe and backup construction that is permitted to be filled with mortar or grout.

COLLECTOR. A horizontal diaphragm element parallel and in line with the applied force that collects and transfers diaphragm shear forces to the vertical elements of the lateral force-resisting system or distributes forces within the diaphragm, or both.

COMBINATION FIRE/SMOKE DAMPER. A listed device installed in ducts and air transfer openings designed to close automatically upon the detection of heat and resist the passage of flame and smoke. The device is installed to operate automatically, controlled by a smoke detection system, and where required, is capable of being positioned from a fire command center.

COMBINED PILE RAFT. A geotechnical composite construction that combines the bearing effect of both foundation elements, raft and piles, by taking into account interactions between the foundation elements and the subsoil.

COMBUSTIBLE DUST. Finely divided solid material that is 420 microns or less in diameter and which, when dispersed in air in the proper proportions, could be ignited by a flame, spark or other source of ignition.

COMBUSTIBLE FIBERS. Readily ignitable and free-burning materials in a fibrous or shredded form, such as cocoa fiber, cloth, cotton, excelsior, hay, hemp, henequen, isle, jute, kapok, oakum, rags, sisal, Spanish moss, straw, tow, wastepaper, certain synthetic fibers or other like materials. This definition does not include densely packed baled cotton.

COMMON PATH OF ESCAPE TRAVEL. That portion of exit access travel distance measured from the most remote point of each room, area or space to that point where the occupants have separate and distinct access to two exits or exit access doorways.

COMMON USE. Interior or exterior circulation paths, rooms, spaces or elements that are not for public use and are made available for the shared use of two or more people.

COMPRRESSED GAS. A material or mixture of materials that meets both of the following:

1. Is a gas at 20°C (68°F) or less at 14.7 pounds per square inch atmosphere (psia) (101 kPa) of pressure.

2. Has a boiling point of 20°C (68°F) or less at 14.7 psia (101 kPa) which is either liquefied, nonliquefied or in solution, except those gases which have no other health- or physical-hazard properties are not considered to be compressed until the pressure in the packaging exceeds 41 psia (282 kPa) at 20°C (68°F).
The states of a compressed gas are categorized as follows:

1. Nonliquefied compressed gases are gases, other than those in solution, which are in a packaging under the charged pressure and are entirely gaseous at a temperature of 20°C (68°F).

2. Liquefied compressed gases are gases that, in a packaging under the charged pressure, are partially liquid at a temperature of 68°F (20°C).

3. Compressed gases in solution are nonliquefied gases that are dissolved in a solvent.

4. Compressed gas mixtures consist of a mixture of two or more compressed gases contained in a packaging, the hazard properties of which are represented by the properties of the mixture as a whole.

CONCRETE.

Carbonate aggregate. Concrete made with aggregates consisting mainly of calcium or magnesium carbonate, such as limestone or dolomite, and containing 40 percent or less quartz, chert or flint.

Cellular. A lightweight insulating concrete made by mixing a preformed foam with Portland cement slurry and having a dry unit weight of approximately 30 pcf (480 \( \text{kg/m}^3 \)).

Lightweight aggregate. Concrete made with aggregates of expanded clay, shale, slag or slate or sintered fly ash or any natural lightweight aggregate meeting ASTM C330 and possessing equivalent fire-resistance properties and weighing 85 to 115 pcf (1360 to 1840 \( \text{kg/m}^3 \)).

Perlite. A lightweight insulating concrete having a dry unit weight of approximately 30 pcf (480 \( \text{kg/m}^3 \)) made with perlite concrete aggregate. Perlite aggregate is produced from a volcanic rock which, when heated, expands to form a glass-like material of cellular structure.

Sand-lightweight. Concrete made with a combination of expanded clay, shale, slag, slate, sintered fly ash, or any natural lightweight aggregate meeting ASTM C330 and possessing equivalent fire-resistance properties and natural sand. Its unit weight is generally between 105 and 120 pcf (1680 and 1920 \( \text{kg/m}^3 \)).

Siliceous aggregate. Concrete made with normal-weight aggregates consisting mainly of silica or compounds other than calcium or magnesium carbonate, which contains more than 40-percent quartz, chert or flint.

Vermiculite. A light weight insulating concrete made with vermiculite concrete aggregate which is laminated micaceous material produced by expanding the ore at high temperatures. When added to a Portland cement slurry the resulting concrete has a dry unit weight of approximately 30 pcf (480 \( \text{kg/m}^3 \)).

CONGREGATE LIVING FACILITIES. A building or part thereof that contains sleeping units where residents share bathroom or kitchen facilities, or both.

CONSTANTLY ATTENDED LOCATION. A designated location at a facility staffed by trained personnel on a continuous basis where alarm or supervisory signals are monitored and facilities are provided for notification of the fire department or other emergency services.

CONSTRUCTION DOCUMENTS. Written, graphic and pictorial documents prepared or assembled for describing the design, location and physical characteristics of the elements of a project necessary for obtaining a building permit.

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior, or is integral to any opaque surface of the building envelope.

CONTROL AREA. Spaces within a building where quantities of hazardous materials not exceeding the maximum allowable quantities per control area are stored, dispensed, used or handled. See the definition of “Outdoor control area” in the Ghana Fire Code.

CONTROLLED LOW-STRENGTH MATERIAL. A self-compacted, cementitious material used primarily as a backfill in place of compacted fill.

CONVENTIONAL LIGHT-FRAME CONSTRUCTION. Construction whose primary structural elements are formed by a system of repetitive wood-framing members.
CORNICE. A projecting horizontal molded element located at or near the top of an architectural feature.

CORRIDOR. An enclosed exit access component that defines and provides a path of escape travel.

CORRIDOR DAMPER. A listed device intended for use where air ducts penetrate or terminate at horizontal openings in the ceilings of fire-resistance-rated corridors, where the corridor ceiling is permitted to be constructed as required for the corridor walls.

CORROSION RESISTANCE. The ability of a material to withstand deterioration of its surface or its properties when exposed to its environment.

CORROSIVE. A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact.

COURT. An open, uncovered space, unobstructed to the sky, bounded on three or more sides by exterior building walls or other enclosing devices.

COVERED MALL BUILDING. A single building enclosing a number of tenants and occupants, such as retail stores, drinking and dining establishments, entertainment and amusement facilities, passenger transportation terminals, offices and other similar uses wherein two or more tenants have a main entrance into one or more malls. Anchor buildings shall not be considered as a part of the covered mall building. The term "covered mall building" shall include open mall buildings as defined below.

Mall. A roofed or covered common pedestrian area within a covered mall building that serves as access for two or more tenants and not to exceed three levels that are open to each other. The term "mall" shall include open malls as defined below.

Open mall. An unroofed common pedestrian way serving a number of tenants not exceeding three levels. Circulation at levels above grade shall be permitted to include open exterior balconies leading to exits discharging at grade.

Open mall building. Several structures housing a number of tenants, such as retail stores, drinking and dining establishments, entertainment and amusement facilities, offices, and other similar uses, wherein two or more tenants have a main entrance into one or more open malls. Anchor buildings are not considered as a part of the open mall building.

CRIPPLE WALL. A framed stud wall extending from the top of the foundation to the underside of floor framing for the lowest occupied floor level.

CRITICAL CIRCUIT. A circuit that requires continuous operation to ensure safety of the structure and occupants.

CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn timber or structural composite timber where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

CRYOGENIC FLUID. A liquid having a boiling point lower than -150°F (-101°C) at 14.7 pounds per square inch atmosphere (psia) (an absolute pressure of 101 kPa).

CUSTODIAL CARE. Assistance with day-to-day living tasks; such as assistance with cooking, taking medication, bathing, using toilet facilities and other tasks of daily living. Custodial care includes persons receiving care who have the ability to respond to emergency situations and evacuate at a slower rate and/or who have mental and psychiatric complications.

DALLE GLASS. A decorative composite glazing material made of individual pieces of glass that are embedded in a cast matrix of concrete or epoxy.

DANGEROUS. Any building, structure or portion thereof that meets any of the conditions described below shall be deemed dangerous:

1. The building or structure has collapsed, has partially collapsed, has moved off its foundation or lacks the necessary support of the ground.

2. There exists a significant risk of collapse, detachment or dislodgment of any portion, member, appurtenance or ornamentation of the building or structure under service loads.

DAY BOX. A portable magazine designed to hold explosive materials constructed in accordance with the requirements for a Type 3 magazine as defined and classified in Part 56 of the Ghana Fire Code.
DEAD LOAD. The weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items, and the weight of fixed service equipment, such as cranes, plumbing stacks and risers, electrical feeders, heating, ventilating and air-conditioning systems and automatic sprinkler systems.

DECORATIVE GLASS. A carved, leaded or Dalle glass or glazing material whose purpose is decorative or artistic, not functional; whose coloring, texture or other design qualities or components cannot be removed without destroying the glazing material and whose surface, or assembly into which it is incorporated, is divided into segments.

DECORATIVE MATERIALS. All materials applied over the building interior finish for decorative, acoustical or other effect including, but not limited to, curtains, draperies, fabrics and streamers; and all other materials utilized for decorative effect including, but not limited to, bulletin boards, artwork, posters, photographs, batting, cloth, cotton, hay, stalks, straw, vines, leaves, trees, moss and similar items, foam plastics and materials containing foam plastics. Decorative materials do not include wall coverings, ceiling coverings, floor coverings, ordinary window shades, interior finish and materials 0.64 mm (0.025 inch) or less in thickness applied directly to and adhering tightly to a substrate.

DEEP FOUNDATION. A deep foundation is a foundation element that does not satisfy the definition of a shallow foundation.

DEFEND-IN-PLACE. A method of emergency response that engages building components and trained staff to provide occupant safety during an emergency. Emergency response involves remaining in place, relocating within the building, or both, without evacuating the building.

DEFERRED SUBMISSION. Those portions of the design that are not submitted at the time of the application and that are to be submitted to the Head of Works within a specified period.

DEFLAGRATION. An exothermic reaction, such as the extremely rapid oxidation of a flammable dust or vapour in air, in which the reaction progresses through the unburned material at a rate less than the velocity of sound. A deflagration can have an explosive effect.

DELAYED-ACTION CLOSER. A self-closing device that incorporates a delay prior to the initiation of closing. Delayed-action closers are mechanical devices with an adjustable delay.

DELUGE SYSTEM. A sprinkler system employing open sprinklers attached to a piping system connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

DESIGN EARTHQUAKE GROUND MOTION. The earthquake ground motion that buildings and structures are specifically proportioned to resist in this Code.

DESIGN FLOOD. The flood associated with the greater of the following two areas:

1. Area with a flood plain subject to a 1-percent or greater chance of flooding in any year.

2. Area designated as a flood hazard area on a community’s flood hazard map, or otherwise legally designated.

DESIGN FLOOD ELEVATION. The elevation of the “design flood,” including wave height, relative to the datum specified on the community's legally designated flood hazard map.

DESIGN STRENGTH. The product of the nominal strength and a resistance factor (or strength reduction factor).

DETACHED BUILDING. A separate single-storey building, without a basement or crawl space, used for the storage or use of hazardous materials and located an approved distance from all structures.

DETECTABLE WARNING. A standardized surface feature built in or applied to walking surfaces or other elements to warn visually impaired persons of hazards on a circulation path.

DETECTOR, HEAT. A fire detector that senses heat—either abnormally high temperature or rate of rise, or both.

DETONATION. An exothermic reaction characterized by the presence of a shock wave
in the material which establishes and maintains the reaction. The reaction zone progresses through the material at a rate greater than the velocity of sound. The principal heating mechanism is one of shock compression. Detonations have an explosive effect.

**DETOXIFICATION FACILITIES.** Facilities that provide treatment for substance abuse, serving care recipients who are incapable of self-preservation or who are harmful to themselves or others.

**DIAPHRAGM.** A horizontal or sloped system acting to transmit lateral forces to vertical elements of the lateral force-resisting system. When the term “diaphragm” is used, it shall include horizontal bracing systems.

Diaphragm, blocked. In light-frame construction, a diaphragm in which all sheathing edges not occurring on a framing member are supported on and fastened to blocking.

Diaphragm boundary. In light-frame construction, a location where shear is transferred into or out of the diaphragm sheathing. Transfer is either to a boundary element or to another force-resisting element.

Diaphragm chord. A diaphragm boundary element perpendicular to the applied load that is assumed to take axial stresses due to the diaphragm moment.

Diaphragm, unblocked. A diaphragm that has edge nailing at supporting members only. Blocking between supporting structural members at panel edges is not included. Diaphragm panels are field nailed to supporting members.

**DIRECT ACCESS.** A path of travel from a space to an immediately adjacent space through an opening in the common wall between the two spaces.

**DISPENSING.** The pouring or transferring of any material from a container, tank or similar vessel, whereby vapours, dusts, fumes, mists or gases are liberated to the atmosphere.

**DORMITORY.** A space in a building where group sleeping accommodations are provided in one room, or in a series of closely associated rooms, for persons not members of the same family group, under joint occupancy and single management, as in college dormitories or fraternity houses.

**DRAFTSTOP.** A material, device or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor/ceiling assemblies, roof/ceiling assemblies and attics.

**DRILLED SHAFT.** A cast-in-place deep foundation element, also referred to as a caisson, drilled pier or bored pile, constructed by drilling a hole (with or without permanent casing or drilling fluid) into soil or rock and filling it with fluid concrete after the drilling equipment is removed.

Socketed drilled shaft. A drilled shaft with a permanent pipe or tube casing that extends down to bedrock and an uncased socket drilled into the bedrock.

**DRY-CHEMICAL EXTINGUISHING AGENT.** A powder composed of small particles, usually of sodium bicarbonate, potassium bicarbonate, urea-potassium-based bicarbonate, potassium chloride or monoammonium phosphate, with added particulate material supplemented by special treatment to provide resistance to packing, resistance to moisture absorption (caking) and the proper flow capabilities.

**DRY FLOODPROOFING.** A combination of design modifications that results in a building or structure, including the attendant utilities and equipment and sanitary facilities, being water tight with walls substantially impermeable to the passage of water and with structural components having the capacity to resist loads.

**DWELLING.** A building that contains one or two dwelling units used, intended or designed to be used, rented, leased, let or hired out to be occupied for living purposes.

**DWELLING UNIT.** A single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

**ESCAPE COURT.** A court or yard which provides access to a public way for one or more exits.

**ELECTRICAL CIRCUIT PROTECTIVE SYSTEM.** A specific construction of devices, materials, or coatings installed as a fire-resistive barrier system applied to electrical system components, such as cable trays,
conduits and other raceways, open run cables and conductors, cables, and conductors.

ELEVATOR GROUP. A grouping of elevators in a building located adjacent or directly across from one another that responds to common hall call buttons.

EMERGENCY ALARM SYSTEM. A system to provide indication and warning of emergency situations involving hazardous materials.

EMERGENCY CONTROL STATION. An approved location on the premises where signals from emergency equipment are received and which is staffed by trained personnel.

EMERGENCY ESCAPE AND RESCUE OPENING. An operable window, door or other similar device that provides for a means of escape and access for rescue in the event of an emergency.

EMERGENCY FACILITIES. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, or earthquakes.

EMERGENCY POWER SYSTEM. A source of automatic electric power of a required capacity and duration to operate required life safety, fire alarm, detection and ventilation systems in the event of a failure of the primary power. Emergency power systems are required for electrical loads where interruption of the primary power could result in loss of human life or serious injuries.

EMERGENCY VOICE/ALARM COMMUNICATIONS. Dedicated manual or automatic facilities for originating and distributing voice instructions, as well as alert and evacuation signals pertaining to a fire emergency, to the occupants of a building.

EMPLOYEE WORK AREA. All or any portion of a space used only by employees and only for work. Corridors, toilet rooms, kitchenettes and break rooms are not employee work areas.

ENGINEERED WOOD RIM BOARD. A full-depth structural composite timber, wood structural panel, structural glued laminated timber or prefabricated wood I-Joist member designed to transfer horizontal (shear) and vertical (compression) loads, provide attachment for diaphragm sheathing, siding and exterior deck ledgers, and provide lateral support at the ends of floor or roof joists or rafters.

EQUIPMENT PLATFORM. An unoccupied, elevated platform used exclusively for mechanical systems or industrial process equipment, including the associated elevated walkways, stairways, alternating tread devices and ladders necessary to access the platform.

EXHAUSTED ENCLOSURE. An appliance or piece of equipment that consists of a top, a back and two sides providing a means of local exhaust for capturing gases, fumes, vapours and mists. Such enclosures include laboratory hoods, exhaust fume hoods and similar appliances and equipment used to locally retain and exhaust the gases, fumes, vapours and mists that could be released. Rooms or areas provided with general ventilation, in themselves, are not exhausted enclosures.

EXISTING BUILDING. A building erected prior to the date of adoption of the appropriate Code, or one for which a legal building permit has been issued.

EXISTING STRUCTURE. A structure erected prior to the date of adoption of the appropriate Code, or one for which a legal building permit has been issued.

EXIT. That portion of a means of escape system between the exit access and the exit discharge or public way. Exit components include exterior exit doors at the level of exit discharge, interior exit stairways and ramps, exit passageways, exterior exit stairways and ramps and horizontal exits.

EXIT ACCESS. That portion of a means of escape system that leads from any occupied portion of a building or structure to an exit.

EXIT ACCESS DOORWAY. A door or access point along the path of escape travel from an occupied room, area or space where the path of escape enters an intervening room, corridor, exit access stairway or ramp.

EXIT ACCESS RAMP. A ramp within the exit access portion of the means of escape system.

EXIT ACCESS STAIRWAY. A stairway within the exit access portion of the means of escape system.

EXIT DISCHARGE. That portion of a means of escape system between the termination of an exit and a public way.
EXIT DISCHARGE, LEVEL OF. The storey at the point at which an exit terminates and an exit discharge begins.

EXIT PASSAGEWAY. An exit component that is separated from other interior spaces of a building or structure by fire-resistance-rated construction and opening protective, and provides for a protected path of escape travel in a horizontal direction to an exit or to the exit discharge.

EXPANDED VINYL WALL COVERING. Wall covering consisting of a woven textile backing, an expanded vinyl base coat layer and a nonexpanded vinyl skin coat. The expanded base coat layer is a homogeneous vinyl layer that contains a blowing agent. During processing, the blowing agent decomposes, causing this layer to expand by forming closed cells. The total thickness of the wall covering is approximately 1.4 mm to 1.78 mm (0.055 inch to 0.070 inch).

EXPLOSION. An effect produced by the sudden violent expansion of gases, which may be accompanied by a shock wave or disruption, or both, of enclosing materials or structures. An explosion could result from any of the following:

1. Chemical changes such as rapid oxidation, deflagration or detonation, decomposition of molecules and runaway polymerization (usually detonations).
2. Physical changes such as pressure tank ruptures.
3. Atomic changes (nuclear fission or fusion).

EXPLOSIVE. A chemical compound, mixture or device, the primary or common purpose of which is to function by explosion. The term includes, but is not limited to: dynamite, black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, and igniters.

EXTERIOR EXIT RAMP. An exit component that serves to meet one or more means of escape design requirements, such as required number of exits or exit access travel distance, and is open to yards, courts or public ways.

EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS). EIFS are nonstructural, nonload-bearing, exterior wall cladding systems that consist of an insulation board attached either adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat and a textured protective finish coat.

EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS) WITH DRAINAGE. An EIFS that incorporates a means of drainage applied over a water-resistive barrier.

EXTERIOR SURFACES. Weather-exposed surfaces.

EXTERIOR WALL. A wall, bearing or nonbearing, that is used as an enclosing wall for a building, other than a fire wall, and that has a slope of 60 degrees (1.05 rad) or greater with the horizontal plane.

EXTERIOR WALL COVERING. A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resisting barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, facias, gutters and leaders.

EXTERIOR WALL ENVELOPE. A system or assembly of exterior wall components, including exterior wall finish materials, that provides protection of the building structural members, including framing and sheathing materials, and conditioned interior space, from the detrimental effects of the exterior environment.

FABRIC PARTITION. A partition consisting of a finished surface made of fabric, without a continuous rigid backing, that is directly attached to a framing system in which the vertical framing members are spaced greater than 1219 mm (4 feet) on center.

FABRICATED ITEM. Structural, load-bearing or lateral load-resisting members or assemblies consisting of materials assembled prior to installation in a building or structure, or subjected to operations such as heat treatment, thermal cutting, cold working or reforming after manufacture and prior to installation in a building or structure. Materials produced in accordance with standards referenced by this Code, such as rolled structural steel shapes,
steel reinforcing bars, masonry units and wood structural panels, or in accordance with a referenced standard that provides requirements for quality control done under the supervision of a third-party quality control agency, are not “fabricated items.”

FABRICATION AREA. An area within a semiconductor fabrication facility and related research and development areas in which there are processes using hazardous production materials. Such areas are allowed to include ancillary rooms or areas such as dressing rooms and offices that are directly related to the fabrication area processes.

FACILITY. All or any portion of buildings, structures, site improvements, elements and pedestrian or vehicular routes located on a site.

FACTORED LOAD. The product of a nominal load and a load factor.

FENESTRATION. Products classified as either vertical fenestration or skylights and sloped glazing, installed in such a manner as to preserve the weather-resistant barrier of the wall or roof in which they are installed. Fenestration includes products with glass or other transparent or translucent materials.

FENESTRATION, VERTICAL. Windows that are fixed or movable, opaque doors, glazed doors, glazed block and combination opaque and glazed doors installed in a wall at less than 15 degrees from the vertical.

FIBER-CEMENT (BACKER BOARD, SIDING, SOFFIT, TRIM AND UNDERLAYMENT) PRODUCTS. Manufactured thin clause composites of hydraulic cementitious matrices and discrete nonasbestos fibers.

FIBER-REINFORCED POLYMER. A polymeric composite material consisting of reinforcement fibers, such as glass, impregnated with a fiber-binding polymer which is then molded and hardened. Fiber-reinforced polymers are permitted to contain cores laminated between fiber-reinforced polymer facings.

FIBERBOARD. A fibrous, homogeneous panel made from lignocellulosic fibers (usually wood or cane) and having a density of less than 31 pounds per cubic foot (pcf) (497 kg/m$^3$) but more than 10 pcf (160 kg/m$^3$).

FIRE ALARM CONTROL UNIT. A system component that receives inputs from automatic and manual fire alarm devices and may be capable of supplying power to detection devices and transponders or off-premises transmitters. The control unit may be capable of providing a transfer of power to the notification appliances and transfer of condition to relays or devices.

FIRE ALARM SIGNAL. A signal initiated by a fire alarm-initiating device such as a manual fire alarm box, automatic fire detector, workflow switch or other device whose activation is indicative of the presence of a fire or fire signature.

FIRE ALARM SYSTEM. A system or portion of a combination system consisting of components and circuits arranged to monitor and annunciate the status of fire alarm or supervisory signal-initiating devices and to initiate the appropriate response to those signals.

FIRE AREA. The aggregate floor area enclosed and bounded by fire walls, fire barriers, exterior walls or horizontal assemblies of a building. Areas of the building not provided with surrounding walls shall be included in the fire area if such areas are included within the horizontal projection of the roof or floor next above.

FIRE BARRIER. A fire-resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained.

FIRE COMMAND CENTER. The principal attended or unattended location where the status of detection, alarm communications and control systems is displayed, and from which the systems can be manually controlled.

FIRE DAMPER. A listed device installed in ducts and air transfer openings designed to close automatically upon detection of heat and resist the passage of flame. Fire dampers are classified for use in either static systems that will automatically shut down in the event of a fire, or in dynamic systems that continue to operate during a fire. A dynamic fire damper is tested and rated for closure under elevated temperature airflow.

FIRE DETECTOR, AUTOMATIC. A device designed to detect the presence of a fire signature and to initiate action.

FIRE DOOR. The door component of a fire door assembly.

FIRE DOOR ASSEMBLY. Any combination of a fire door, frame, hardware and other
accessories that together provide a specific degree of fire protection to the opening.

FIRE EXIT HARDWARE. Panic hardware that is listed for use on fire door assemblies.

FIRE LANE. A road or other passageway developed to allow the passage of fire apparatus. A fire lane is not necessarily intended for vehicular traffic other than fire apparatus.

FIRE PARTITION. A vertical assembly of materials designed to restrict the spread of fire in which openings are protected.

FIRE PROTECTION RATING. The period of time that an opening protective will maintain the ability to confine a fire as determined by tests specified in this Code. Ratings are stated in hours or minutes.

FIRE PROTECTION SYSTEM. Approved devices, equipment and systems or combinations of systems used to detect a fire, activate an alarm, extinguish or control a fire, control or manage smoke and products of a fire or any combination thereof.

FIRE RATING. The time period that the through-penetration firestop system limits the spread of fire through the penetration when tested in accordance with ASTM E814.

FIRE-RATED GLAZING. Glazing with either a fire protection rating or a fire-resistance rating.

FIRE RESISTANCE. That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.

FIRE-RESISTANCE RATING. The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in this Code.

FIRE-RESISTANT JOINT SYSTEM. An assemblage of specific materials or products that are designed, tested and fire-resistance rated in accordance with either ASTM E1966 to resist for a prescribed period of time the passage of fire through joints made in or between fire-resistance-rated assemblies.

FIRE SAFETY FUNCTIONS. Building and fire control functions that are intended to increase the level of life safety for occupants or to control the spread of harmful effects of fire.

FIRE SEPARATION DISTANCE. The distance measured from the building face to one of the following:

1. The closest interior plot line.
2. To the centerline of a street, an alley or public way.
3. To an imaginary line between two buildings on the plot.

The distance shall be measured at right angles from the face of the wall.

FIRE WALL. A fire-resistance-rated wall having protected openings, which restricts the spread of fire and extends continuously from the foundation to or through the roof, with sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall.

FIRE WINDOW ASSEMBLY. A window constructed and glazed to give protection against the passage of fire.

FIREBLOCKING. Building materials, or materials approved for use as fireblocking, installed to resist the free passage of flame to other areas of the building through concealed spaces.

FIREPLACE. A hearth and fire chamber or similar prepared place in which a fire may be made and which is built in conjunction with a chimney.

FIREPLACE THROAT. The opening between the top of the firebox and the smoke chamber.

FIXED BASE OPERATOR (FBO). A commercial business granted the right by the airport sponsor to operate on an airport and provide aeronautical services, such as fueling, hangaring, tie-down and parking, aircraft rental, aircraft maintenance and flight instruction.

FIXED SEATING. Furniture or fixture designed and installed for the use of sitting and secured in place including bench-type seats and seats with or without backs or armrests.

FLAME SPREAD. The propagation of flame over a surface.

FLAME SPREAD INDEX. A comparative measure, expressed as a dimensionless
number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E84.

**FLAMMABLE GAS.** A material that is a gas at 68°F (20°C) or less at 14.7 pounds per square inch atmosphere (psia) (101 kPa) of pressure [a material that has a boiling point of 68°F (20°C) or less at 14.7 psia (101 kPa)], which also meets one of the following:

1. Is ignitable at 14.7 psia (101 kPa) when in a mixture of 13 percent or less by volume with air.

2. Has a flammable range at 14.7 psia (101 kPa) with air of at least 12 percent, regardless of the lower limit.

The limits specified shall be determined at 14.7 psi (101 kPa) of pressure and a temperature of 68°F (20°C) in accordance with ASTM E681.

**FLAMMABLE LIQUEFIED GAS.** A liquefied compressed gas which, under a charged pressure, is partially liquid at a temperature of 68°F (20°C) and which is flammable.

**FLAMMABLE MATERIAL.** A material capable of being readily ignited from common sources of heat or at a temperature of 600°F (316°C) or less.

**FLAMMABLE SOLID.** A solid, other than a blasting agent or explosive, that is capable of causing fire through friction, absorption or moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which has an ignition temperature below 100°C (212°F) or which burns so vigorously and persistently when ignited as to create a serious hazard.

**FLAMMABLE VAPOURS OR FUMES.** The concentration of flammable constituents in air that exceeds 25 percent of their lower flammable limit (LFL).

**FLASH POINT.** The minimum temperature in degrees Celsius at which a liquid will give off sufficient vapours to form an ignitable mixture with air near the surface or in the container, but will not sustain combustion.

**FLIGHT.** A continuous run of treads, winders or combination thereof from one landing to another.

**FLOOD or FLOODING.** A general and temporary condition of partial or complete inundation of normally dry land from:

1. The overflow of inland or tidal waters.

2. The unusual and rapid accumulation or runoff of surface waters from any source.

**FLOOD DAMAGE-RESISTANT MATERIALS.** Any construction material capable of withstanding direct and prolonged contact with floodwaters without sustaining any damage that requires more than cosmetic repair.

**FLOOD HAZARD AREA.** The greater of the following two areas:

1. The area within a flood plain subject to a 1-percent or greater chance of flooding in any year.

2. The area designated as a flood hazard area on a community’s flood hazard map, or otherwise legally designated.

**FLOODWAY.** The channel of the river, creek or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

**FLOOR AREA, GROSS.** The floor area within the inside perimeter of the exterior walls of the building under consideration, exclusive of vent shafts and courts, without deduction for corridors, stairways, ramps, closets, the thickness of interior walls, columns or other features. The floor area of a building, or portion thereof, not provided with surrounding exterior walls shall be the usable area under the horizontal projection of the roof or floor above. The gross floor area shall not include shafts with no openings or interior courts.

**FLOOR AREA, NET.** The actual occupied area not including unoccupied accessory areas such as corridors, stairways, ramps, toilet rooms, mechanical rooms and closets.

**FLOOR FIRE DOOR ASSEMBLY.** A combination of a fire door, a frame, hardware and other accessories installed in a horizontal plane, which together provide a specific degree of fire protection to a through-opening in a fire-resistance-rated floor.

**FOAM-EXTINGUISHING SYSTEM.** A special system discharging a foam made from
concentrates, either mechanically or chemically, over the area to be protected.

**FOAM PLASTIC INSULATION.** A plastic that is intentionally expanded by the use of a foaming agent to produce a reduced-density plastic containing voids consisting of open or closed cells distributed throughout the plastic for thermal insulating or acoustical purposes and that has a density less than 20 pounds per cubic foot (pcf) (320 kg/m³).

**FOLDING AND TELESCOPIC SEATING.** Tiered seating having an overall shape and size that is capable of being reduced for purposes of moving or storing and is not a building element.

**FOOD COURT.** A public seating area located in the mall that serves adjacent food preparation tenant spaces.

**FOSTER CARE FACILITIES.** Facilities that provide care to more than five children, 1/2 years of age or less.

**FOUNDATION PIER (for Part 21).** An isolated vertical foundation member whose horizontal dimension measured at right angles to its thickness does not exceed three times its thickness and whose height is equal to or less than four times its thickness.

**FRAME STRUCTURE.** A building or other structure in which vertical loads from floors and roofs are primarily supported by columns.

**FUEL CELL POWER SYSTEM, STATIONARY.** A stationary energy-generation system that converts the chemical energy of a fuel and oxidant to electric energy (DC or AC electricity) by an electrochemical process.

**Field-fabricated fuel cell power system.** A stationary fuel cell power system that is assembled at the job site and is not a preengineered or prepackaged factory-assembled fuel cell power system.

**Preengineered fuel cell power system.** A stationary fuel cell power system consisting of components and modules that are produced in a factory and shipped to the job site for assembly.

**Prepackaged fuel cell power system.** A stationary fuel cell power system that is factory assembled as a single, complete unit and shipped as a complete unit for installation at the job site.

**GABLE.** The triangular portion of a wall beneath the end of a dual-slope, pitched, or mono-slope roof or portion thereof and above the top plates of the storey or level of the ceiling below.

**GAMING.** To deal, operate, carry on, conduct, maintain or expose for play any game played with cards, dice, equipment or any mechanical, electromechanical or electronic device or machine for money, property, checks, credit or any representative of value except where occurring at private home or operated by a charitable or educational organization.

**GAMING AREA.** Single or multiple areas of a building or facility where gaming machines or tables are present and gaming occurs, including but not limited to, primary casino gaming areas, VIP gaming areas, high-roller gaming areas, bar tops, lobbies, dedicated rooms or spaces such as in retail or restaurant establishments, sports books and tournament areas.

**GAMING MACHINE TYPE.** Categorization of gaming machines per type of game played on them, including but not limited to, slot machines, video poker and video keno.

**GAMING TABLE TYPE.** Categorization of gaming tables per the type of game played on them, including, but not limited to, baccarat, bingo, blackjack/21, craps, pai gow, poker, roulette.

**GAS CABINET.** A fully enclosed, ventilated noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage or use. Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are allowed to be included.

**GAS DETECTION SYSTEM.** A system or portion of a combination system that utilizes one or more stationary sensors to detect the presence of a specified gas at a specified concentration and initiate one or more responses required by this Code, such as notifying a responsible person, activating an alarm signal, or activating or deactivating equipment. A self-contained gas detection and alarm device is not classified as a gas detection system.

**GAS ROOM.** A separately ventilated, fully enclosed room in which only compressed...
gases and associated equipment and supplies are stored or used.

**GASEOUS HYDROGEN SYSTEM.** An assembly of piping, devices and apparatus designed to generate, store, contain, distribute or transport a nontoxic, gaseous hydrogen-containing mixture having not less than 95-percent hydrogen gas by volume and not more than 1-percent oxygen by volume. Gaseous hydrogen systems consist of items such as compressed gas containers, reactors and appurtenances, including pressure regulators, pressure relief devices, manifolds, pumps, compressors and interconnecting piping and tubing and controls.

**GLASS FIBERBOARD.** Fibrous glass roof insulation consisting of inorganic glass fibers formed into rigid boards using a binder. The board has a top surface faced with asphalt and kraft reinforced with glass fiber.

**GRADE (TIMBER).** The classification of timber in regard to strength and utility with Ghana Standards Grading Rules.

**GRADE FLOOR OPENING.** A window or other opening located such that the sill height of the opening is not more than 44 inches (1118 mm) above or below the finished ground level adjacent to the opening.

**GRADE PLANE.** A reference plane representing the average of finished ground level adjoining the building at exterior walls. Where the finished ground level slopes away from the exterior walls, the reference plane shall be established by the lowest points within the area between the building and the plot line or, where the plot line is more than 1829 mm (6 feet) from the building, between the building and a point 1829 mm (6 feet) from the building.

**GRANDSTAND.** Tiered seating supported on a dedicated structural system and two or more rows high and is not a building element.

**GREENHOUSE.** A structure or thermally isolated area of a building that maintains a specialized sunlit environment used for and essential to the cultivation, protection or maintenance of plants.

**GROSS LEASABLE AREA.** The total floor area designed for tenant occupancy and exclusive use. The area of tenant occupancy is measured from the centerlines of joint partitions to the outside of the tenant walls. All tenant areas, including areas used for storage, shall be included in calculating gross leasable area.

**GROUP HOME.** A facility for social rehabilitation, substance abuse or mental health problems that contains a group housing arrangement that provides custodial care but does not provide medical care.

**GUARD.** A building component or a system of building components located at or near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to a lower level.

**GUESTROOM.** A room used or intended to be used by one or more guests for living or sleeping purposes.

**GYPSUM BOARD.** The generic name for a family of sheet products consisting of a noncombustible core primarily of gypsum with paper surfacing. Gypsum wallboard, gypsum sheathing, gypsum base for gypsum veneer plaster, exterior gypsum soffit board, predecorated gypsum board and water-resistant gypsum backing board.

**GYPSUM PANEL PRODUCT.** The general name for a family of sheet products consisting essentially of gypsum.

**GYPSUM PLASTER.** A mixture of calcined gypsum or calcined gypsum and lime and aggregate and other approved materials as specified in this Code.

**GYPSUM VENEER PLASTER.** Gypsum plaster applied to an approved base in one or more coats normally not exceeding 6.4 mm (\(\frac{1}{4}\) inch) in total thickness.

**HABITABLE SPACE.** A space in a building for living, sleeping, eating or cooking. Bathrooms, toilet rooms, closets, halls, storage or utility spaces and similar areas are not considered habitable spaces.

**HALOGENATED EXTINGUISHING SYSTEM.** A fire-extinguishing system using one or more atoms of an element from the halogen chemical series: fluorine, chlorine, bromine and iodine.

**HANDLING.** The deliberate transport by any means to a point of storage or use.

**HANDRAIL.** A horizontal or sloping rail intended for grasping by the hand for guidance or support.

**HARDBOARD.** A fibrous-felted, homogeneous panel made from lignocellulosic fibers
consolidated under heat and pressure in a hot press to a density not less than 31 pcf (497 kg/m3).

HAZARDOUS MATERIALS. Those chemicals or substances that are physical hazards or health hazards as classified in this Code and the Ghana Fire Code, whether the materials are in usable or waste condition.

HAZARDOUS PRODUCTION MATERIAL (HPM). A solid, liquid or gas associated with semiconductor manufacturing that has a degree-of-hazard rating in health, flammability or instability of Class 3 or 4 as ranked by the Ghana Fire Code and which is used directly in research, laboratory or production processes which have as their end product materials that are not hazardous.

HEAD JOINT. Vertical mortar joint placed between masonry units within the Wythe at the time the masonry units are laid.

HEALTH HAZARD. A classification of a chemical for which there is statistically significant evidence that acute or chronic health effects are capable of occurring in exposed persons. The term "health hazard" includes chemicals that are toxic or highly toxic, and corrosive.

HEIGHT, BUILDING. The vertical distance from grade plane to the average height of the highest roof surface.

HELICAL PILE. Manufactured steel deep foundation element consisting of a central shaft and one or more helical bearing plates. A helical pile is installed by rotating it into the ground. Each helical bearing plate is formed into a screw thread with a uniform defined pitch.

HELIPAD. A structural surface that is used for the landing, taking off, taxiing and parking of helicopters.

HELIPORT. An area of land or water or a structural surface that is used, or intended for use, for the landing and taking off of helicopters, and any appurtenant areas that are used, or intended for use, for heliport buildings or other heliport facilities.

HELISTOP. The same as "heliport," except that no fueling, defueling, maintenance, repairs or storage of helicopters is permitted.

HIGHER EDUCATION LABORATORY. Laboratories in Group B occupancies used for educational purposes above the 12th grade. Storage, use and handling of chemicals in such laboratories shall be limited to purposes related to testing, analysis, teaching, research or developmental activities on a nonproduction basis.

HIGHLY TOXIC. A material which produces a lethal dose or lethal concentration that falls within any of the following categories:

1. A chemical that has a median lethal dose (LD₅₀) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

2. A chemical that has a median lethal dose (LD₅₀) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.

3. A chemical that has a median lethal concentration (LC₅₀) in air of 200 parts per million by volume or less of gas or vapour, or 2 milligrams per liter or less of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

Mixtures of these materials with ordinary materials, such as water, might not warrant classification as highly toxic. While this system is basically simple in application, any hazard evaluation that is required for the precise categorization of this type of material shall be performed by experienced, technically competent persons.

HIGH-PRESSURE DECORATIVE EXTERIOR-GRADE COMPACT LAMINATE (HPL). Panels consisting of layers of cellulose fibrous material impregnated with thermosetting resins and bonded together by a high-pressure process to form a homogeneous nonporous core suitable for exterior use.

HIGH-PRESSURE DECORATIVE EXTERIOR-GRADE COMPACT LAMINATE (HPL) SYSTEM. An exterior wall covering fabricated using HPL in a specific assembly including joints, seams, attachments, substrate,
framing and other details as appropriate to a particular design.

**HIGH-RISE BUILDING.** A building with an occupied floor located more than 75 feet (22 860 mm) above the lowest level of fire department vehicle access.

**HISTORIC BUILDINGS.** Any building or structure that is one or more of the following:

1. Listed or certified as eligible for listing by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, in the National Register of Historic Places.

2. Designated as historic under an applicable state or local law.

3. Certified as a contributing resource within a National Register, state designated or locally designated historic district.

**HORIZONTAL ASSEMBLY.** A fire-resistance-rated floor or roof assembly of materials designed to restrict the spread of fire in which continuity is maintained.

**HORIZONTAL EXIT.** An exit component consisting of fire-resistance-rated construction and opening protective intended to compartmentalize portions of a building thereby creating refuge areas that afford safety from the fire and smoke from the area of fire origin.

**HOSPITALS AND PSYCHIATRIC HOSPITALS.** Facilities that provide care or treatment for the medical, psychiatric, obstetrical, or surgical treatment of care recipients who are incapable of self-preservation.

**HOUSING UNIT.** A dormitory or a group of cells with a common dayroom in Group I-3.

**HPM ROOM.** A room used in conjunction with or serving a Group H-5 occupancy, where HPM is stored or used and which is classified as a Group H-2, H-3 or H-4 occupancy.

**HYDROGEN FUEL GAS ROOM.** A room or space that is intended exclusively to house a gaseous hydrogen system.

**IMMEDIATELY DANGEROUS TO LIFE AND HEALTH (IDLH).** The concentration of airborne contaminants which poses a threat of death, immediate or delayed permanent adverse health effects, or effects that could prevent escape from such an environment. This contaminant concentration level is established by the National Institute of Occupational Safety and Health (NIOSH) based on both toxicity and flammability.

**IMPACT LOAD.** The load resulting from moving machinery, elevators, cranes, vehicles and other similar forces and kinetic loads, pressure and possible surcharge from fixed or moving loads.

**INCOMPATIBLE MATERIALS.** Materials that, when mixed, have the potential to react in a manner that generates heat, fumes, gases or byproducts which are hazardous to life or property.

**INERT GAS.** A gas that is capable of reacting with other materials only under abnormal conditions such as high temperatures, pressures and similar extrinsic physical forces. Within the context of the Code, inert gases do not exhibit either physical or health hazard properties as defined (other than acting as a simple asphyxiant) or hazard properties other than those of a compressed gas. Some of the more common inert gases include argon, helium, krypton, neon, nitrogen and xenon.

**INITIATING DEVICE.** A system component that originates transmission of a change-of-state condition, such as in a smoke detector, manual fire alarm box or supervisory switch.

**INTERIOR EXIT RAMP.** An exit component that serves to meet one or more means of escape design requirements, such as required number of exits or exit access travel distance, and provides for a protected path of escape travel to the exit discharge or public way.

**INTERIOR EXIT STAIRWAY.** An exit component that serves to meet one or more means of escape design requirements, such as required number of exits or exit access travel distance, and provides for a protected path of escape travel to the exit discharge or public way.

**INTERIOR FINISH.** Interior finish includes interior wall and ceiling finish and interior floor finish.

**INTERIOR FLOOR FINISH.** The exposed floor surfaces of buildings including coverings applied over a finished floor or stair, including risers.

**INTERIOR FLOOR-WALL BASE.** Interior floor finish trim used to provide a functional or
decorative border at the interclause of walls and floors.

INTERIOR SURFACES. Surfaces other than weather exposed surfaces.

INTERIOR WALL AND CEILING FINISH. The exposed interior surfaces of buildings, including but not limited to: fixed or movable walls and partitions; toilet room privacy partitions; columns; ceilings; and interior wainscoting, paneling or other finish applied structurally or for decoration, acoustical correction, surface insulation, structural fire resistance or similar purposes, but not including trim.

INTERLAYMENT. A layer of felt or nonbituminous saturated felt not less than 18 inches (457 mm) wide, shingled between each course of a wood-shake roof covering.

INTUMESCENT FIRE-RESISTANT COATINGS. Thin film liquid mixture applied to substrates by brush, roller, spray or trowel which expands into a protective foamed layer to provide fire-resistant protection of the substrates when exposed to flame or intense heat.

JOINT. The opening in or between adjacent assemblies that is created due to building tolerances, or is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.

JURISDICTION. The governmental agency that has adopted this Code.

LABEL. An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material and the name and identification of an approved agency, and that indicates that the representative sample of the product or material has been tested and evaluated by an approved agency.

LABORATORY SUITE. A fire-rated, enclosed laboratory area providing one or more laboratory spaces within a Group B educational occupancy that includes ancillary uses such as offices, bathrooms and corridors that are contiguous with the laboratory area.

LIGHT-DIFFUSING SYSTEM. Construction consisting in whole or in part of lenses, panels, grids and baffles made with light-transmitting plastics positioned below independently mounted electrical light sources, skylights or light-transmitting plastic roof panels. Lenses, panels, grids and baffles that are part of an electrical fixture shall not be considered as a light-diffusing system.

LIGHT-FRAME CONSTRUCTION. A type of construction whose vertical and horizontal structural elements are primarily formed by a system of repetitive wood or cold-formed steel framing members.

LIGHT-TRANSMITTING PLASTIC ROOF PANELS. Structural plastic panels other than skylights that are fastened to structural members, or panels or sheathing and that are used as light-transmitting media in the plane of the roof.

LIGHT-TRANSMITTING PLASTIC WALL PANELS. Plastic materials that are fastened to structural members, or to structural panels or sheathing, and that are used as light-transmitting media in exterior walls.

LIMIT STATE. A condition beyond which a structure or member becomes unfit for service and is judged to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).

LIQUID. A material that has a melting point that is equal to or less than 20°C (68°F) and a boiling point that is greater than 20°C (68°F) at 14.7 pounds per square inch absolute (psia) (101 kPa). When not otherwise identified, the term “liquid” includes both flammable and combustible liquids.

LIQUID STORAGE ROOM. A room classified as a Group H-3 occupancy used for the storage of flammable or combustible liquids in a closed condition.

LIQUID USE, DISPENSING AND MIXING ROOM. A room in which Class I, II and IIIA flammable or combustible liquids are used, dispensed or mixed in open containers.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the Head of Works and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LIVE/WORK UNIT. A dwelling unit or sleeping unit in which a significant portion of the space
includes a nonresidential use that is operated by the tenant.

LIVE LOAD. A load produced by the use and occupancy of the building or other structure that does not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

LIVE LOAD, ROOF. A load on a roof produced:

1. During maintenance by workers, equipment and materials;
2. During the life of the structure by movable objects such as planters or other similar small decorative appurtenances that are not occupancy related; or
3. By the use and occupancy of the roof such as for roof gardens or assembly areas.

LOAD AND RESISTANCE FACTOR DESIGN (LRFD). A method of proportioning structural members and their connections using load and resistance factors such that no applicable limit state is reached when the structure is subjected to appropriate load combinations. The term “LRFD” is used in the design of steel and wood structures.

LOAD EFFECTS. Forces and deformations produced in structural members by the applied loads.

LOAD FACTOR. A factor that accounts for deviations of the actual load from the nominal load, for uncertainties in the analysis that transforms the load into a load effect, and for the probability that more than one extreme load will occur simultaneously.

LOADS. Forces or other actions that result from the weight of building materials, occupants and their possessions, environmental effects, differential movement and restrained dimensional changes. Permanent loads are those loads in which variations over time are rare or of small magnitude, such as dead loads. All other loads are variable loads (see “Nominal loads”).

LODGING HOUSE. A one-family dwelling where one or more occupants are primarily permanent in nature and rent is paid for guest rooms.

LOW-ENERGY POWER-OPERATED DOOR. A swinging, sliding or folding door that opens automatically upon an action by a pedestrian such as pressing a push plate or waving a hand in front of a sensor. The door closes automatically, and operates with decreased forces and decreased speeds (see “Power-assisted door” and “Power-operated door”).

LOWER FLAMMABLE LIMIT (LFL). The minimum concentration of vapour in air at which propagation of flame will occur in the presence of an ignition source. The LFL is sometimes referred to as “LEL” or “lower explosive limit.”

LOWEST FLOOR. The lowest floor of the lowest enclosed area, including basement, but excluding any unfinished or flood-resistant enclosure, usable solely for vehicle parking, building access or limited storage provided that such enclosure is not built so as to render the structure in violation of Clause 1612.

MAIN WINDFORCE-RESISTING SYSTEM. An assemblage of structural elements assigned to provide support and stability for the overall structure. The system generally receives wind loading from more than one surface.

MANUAL FIRE ALARM BOX. A manually operated device used to initiate an alarm signal.

MANUFACTURER’S DESIGNATION. An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set of rules (see “Label” and “Mark”).

MARK. An identification applied on a product by the manufacturer indicating the name of the manufacturer and the function of a product or material (see “Label” and “Manufacturer’s designation”).

MARQUEE. A canopy that has a top surface which is sloped less than 25 degrees from the horizontal and is located less than 3048 mm (10 feet) from operable openings above or adjacent to the level of the marquee.

MASONRY. A built-up construction or combination of building units or materials of clay, shale, concrete, glass, gypsum, stone or other approved units bonded together with or without mortar or grout or other accepted methods of joining.

Glass unit masonry. Masonry composed of glass units bonded by mortar.
Plain masonry. Masonry in which the tensile resistance of the masonry is taken into consideration and the effects of stresses in reinforcement are neglected.

Reinforced masonry. Masonry construction in which reinforcement acting in conjunction with the masonry is used to resist forces.

Solid masonry. Masonry consisting of solid masonry units laid contiguously with the joints between the units filled with mortar.

Unreinforced (plain) masonry. Masonry in which the tensile resistance of masonry is taken into consideration and the resistance of the reinforcing steel, if present, is neglected.

MASONRY UNIT. Brick, tile, stone, glass block or concrete block conforming to the requirements specified in Clause 22.3.

Hollow. A masonry unit whose net cross-clause area in any plane parallel to the load-bearing surface is less than 75 percent of its gross cross-clause area measured in the same plane.

Solid. A masonry unit whose net cross-clause area in every plane parallel to the load-bearing surface is 75 percent or more of its gross cross-clause area measured in the same plane.

MASTIC FIRE-RESISTANT COATINGS. Liquid mixture applied to a substrate by brush, roller, spray or trovell that provides fire-resistant protection of a substrate when exposed to flame or intense heat.

MEANS OF ESCAPE. A continuous and unobstructed path of vertical and horizontal escape travel from any occupied portion of a building or structure to a public way. A means of escape consists of three separate and distinct parts: the exit access, the exit and the exit discharge.

MECHANICAL-ACCESS OPEN PARKING GARAGES. Open parking garages employing parking machines, lifts, elevators or other mechanical devices for vehicles moving from and to street level and in which public occupancy is prohibited above the street level.

MECHANICAL EQUIPMENT SCREEN. A rooftop structure, not covered by a roof, used to aesthetically conceal plumbing, electrical or mechanical equipment from view.

MEDICAL CARE. Care involving medical or surgical procedures, nursing or for psychiatric purposes.

MEMBRANE-COVERED CABLE STRUCTURE. A nonpressurized structure in which a mast and cable system provides support and tension to the membrane weather barrier and the membrane imparts stability to the structure.

MEMBRANE-COVERED FRAME STRUCTURE. A nonpressurized building wherein the structure is composed of a rigid framework to support a tensioned membrane which provides the weather barrier.

MEMBRANE PENETRATION. A breach in one side of a floor-ceiling, roof-ceiling or wall assembly to accommodate an item installed into or passing through the breach.

MEMBRANE-PENETRATION FIRESTOP. A material, device or construction installed to resist for a prescribed time period the passage of flame and heat through openings in a protective membrane in order to accommodate cables, cable trays, conduit, tubing, pipes or similar items.

MEMBRANE-PENETRATION FIRESTOP SYSTEM. An assemblage consisting of a fire-resistance-rated floor-ceiling, roof-ceiling or wall assembly, one or more penetrating items installed into or passing through the breach in one side of the assembly and the materials or devices, or both, installed to resist the spread of fire into the assembly for a prescribed period of time.

MERCHANDISE PAD. A merchandise pad is an area for display of merchandise surrounded by aisles, permanent fixtures or walls. Merchandise pads contain elements such as nonfixed and moveable fixtures, cases, racks, counters and partitions as indicated in Clause 1.6.2 from which customers browse or shop.

METAL COMPOSITE MATERIAL (MCM). A factory-manufactured panel consisting of metal skins bonded to both faces of a solid plastic core.

METAL COMPOSITE MATERIAL (MCM) SYSTEM. An exterior wall covering fabricated using MCM in a specific assembly including joints, seams, attachments, substrate, framing
and other details as appropriate to a particular design.

**METAL ROOF PANEL.** An interlocking metal sheet having a minimum installed weather exposure of 3 square feet (0.279 m²) per sheet.

**METAL ROOF SHINGLE.** An interlocking metal sheet having an installed weather exposure less than 3 square feet (0.279 m²) per sheet.

**MEZZANINE.** An intermediate level or levels between the floor and ceiling of any storey and in accordance with Clause 505.

**MICROPILE.** A micropile is a bored, grouted-in-place deep foundation element that develops its load-carrying capacity by means of a bond zone in soil, bedrock or a combination of soil and bedrock.

**MINERAL BOARD.** A rigid felted thermal insulation board consisting of either felted mineral fiber or cellular beads of expanded aggregate formed into flat rectangular units.

**MINERAL FIBER.** Insulation composed principally of fibers manufactured from rock, slag or glass, with or without binders.

**MINERAL WOOL.** Synthetic vitreous fiber insulation made by melting predominately igneous rock or furnace slag, and other inorganic materials, and then physically forming the melt into fibers.

**MODIFIED BITUMEN ROOF COVERING.** One or more layers of polymer-modified asphalt sheets. The sheet materials shall be fully adhered or mechanically attached to the substrate or held in place with an approved ballast layer.

**MORTAR.** A mixture consisting of cementitious materials, fine aggregates, water, with or without admixtures, that is used to construct unit masonry assemblies.

**MORTAR, SURFACE-BONDING.** A mixture to bond concrete masonry units that contains hydraulic cement, glass fiber reinforcement with or without inorganic fillers or organic modifiers and water.

**MULTILEVEL ASSEMBLY SEATING.** Seating that is arranged in distinct levels where each level is comprised of either multiple rows, or a single row of box seats accessed from a separate level.

**MULTIPLE-STATION ALARM DEVICE.** Two or more single-station alarm devices that can be interconnected such that actuation of one causes all integral or separate audible alarms to operate. A multiple-station alarm device can consist of one single-station alarm device having connections to other detectors or to a manual fire alarm box.

**MULTIPLE-STATION SMOKE ALARM.** Two or more single-station alarm devices that are capable of interconnection such that actuation of one causes the appropriate alarm signal to operate in all interconnected alarms.

**MULTISTOREY UNIT.** A dwelling unit or sleeping unit with habitable space located on more than one storey.

**NAILING, BOUNDARY.** A special nailing pattern required by design at the boundaries of diaphragms.

**NAILING, EDGE.** A special nailing pattern required by design at the edges of each panel within the assembly of a diaphragm or shear wall.

**NAILING, FIELD.** Nailing required between the sheathing panels and framing members at locations other than boundary nailing and edge nailing.

**NATURALLY DURABLE WOOD.** The heartwood of the following species except for the occasional piece with corner sapwood, provided 90 percent or more of the width of each side on which it occurs is heartwood.

- **Decay resistant.** Redwood, cedar, black locust and black walnut.
- **Termite resistant.** Redwood, Alaska yellow cedar, Eastern red cedar and Western red cedar.

**NOMINAL LOADS.** The magnitudes of the loads specified in Part 16 (dead, live, soil, wind, snow, rain, flood and earthquake).

**NOMINAL SIZE (TIMBER).** The commercial size designation of width and depth, in standard sawn timber and glued-laminated timber grades; somewhat larger than the standard net size of dressed timber, in accordance with Ghana Grading Rules for Square-Edge Sawn Timber.
NONCOMBUSTIBLE MEMBRANE STRUCTURE. A membrane structure in which the membrane and all component parts of the structure are noncombustible.

NONSTRUCTURAL CONCRETE. Any element made of plain or reinforced concrete that is not part of a structural system required to transfer either gravity or lateral loads to the ground.

NORMAL TEMPERATURE AND PRESSURE (NTP). A temperature of 21°C (70°F) and a pressure of 1 atmosphere [14.7 psia (101 kPa)].

NOSING. The leading edge of treads of stairs and of landings at the top of stairway flights.

NUISANCE ALARM. An alarm caused by mechanical failure, malfunction, improper installation or lack of proper maintenance, or an alarm activated by a cause that cannot be determined.

NURSING HOMES. Facilities that provide care, including both intermediate care facilities and skilled nursing facilities where any of the persons are incapable of self-preservation.

OCCUPANT LOAD. The number of persons for which the means of escape of a building or portion thereof is designed.

OCCUPIABLE SPACE. A room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes or in which occupants are engaged at labor, and which is equipped with means of escape and light and ventilation facilities meeting the requirements of this Code.

OPEN PARKING GARAGE. A structure or portion of a structure with the openings as described in this Code on two or more sides that is used for the parking or storage of private motor vehicles as described in this Code.

OPEN SYSTEM. The use of a solid or liquid hazardous material involving a vessel or system that is continuously open to the atmosphere during normal operations and where vapours are liberated, or the product is exposed to the atmosphere during normal operations. Examples of open systems for solids and liquids include dispensing from or into open beakers or containers, dip tank and plating tank operations.

OPEN-AIR ASSEMBLY SEATING. Seating served by means of escape that is not subject to smoke accumulation within or under a structure and is open to the atmosphere.

OPEN-ENDED CORRIDOR. An interior corridor that is open on each end and connects to an exterior stairway or ramp at each end with no intervening doors or separation from the corridor.

OPENING PROTECTIVE. A fire door assembly, fire shutter assembly, fire window assembly or glass-block assembly in a fire-resistance-rated wall or partition.

OPERATING BUILDING. A building occupied in conjunction with the manufacture, transportation or use of explosive materials. Operating buildings are separated from one another with the use of intraplant or intraline distances.

ORTHOGONAL. To be in two horizontal directions, at 90 degrees (1.57 rad) to each other.

OWNER. Any person, agent, operator, entity, firm or corporation having any legal or equitable interest in the property; or recorded in the official records of the state, county or municipality as holding an interest or title to the property; or otherwise having possession or control of the property, including the guardian of the estate of any such person, and the executor or administrator of the estate of such person if ordered to take possession of real property by a court.

PANEL (PART OF A STRUCTURE). The clause of a floor, wall or roof comprised between the supporting frame of two adjacent rows of columns and girders or column bands of floor or roof construction.

PANIC HARDWARE. A door-latching assembly incorporating a device that releases the latch upon the application of a force in the direction of escape travel. See "Fire exit hardware."

PARTICLEBOARD. A generic term for a panel primarily composed of cellulosic materials (usually wood), generally in the form of discrete pieces or particles, as distinguished from fibers. The cellulosic material is combined with synthetic resin or other suitable bonding system by a process in which the interparticle bond is created by the bonding system under heat and pressure.
**Penetration Firestop.** A through-penetration firestop or a membrane-penetration firestop.

**Penthouse.** An enclosed, unoccupied rooftop structure used for sheltering mechanical and electrical equipment, tanks, elevators and related machinery, and vertical shaft openings.

**Performance Category.** A designation of wood structural panels as related to the panel performance used in Part 23.

**Permit.** An official document or certificate issued by the Head of Works that authorizes performance of a specified activity.

**Person.** An individual, heirs, executors, administrators or assigns, and also includes a firm, partnership or corporation, its or their successors or assigns, or the agent of any of the aforesaid.

**Personal Care Service.** The care of persons who do not require medical care. Personal care involves responsibility for the safety of the persons while inside the building.

**Photoluminescent.** Having the property of emitting light that continues for a length of time after excitation by visible or invisible light has been removed.

**Photovoltaic Module.** A complete, environmentally protected unit consisting of solar cells, optics and other components, exclusive of tracker, designed to generate DC power when exposed to sunlight.

**Photovoltaic Panel.** A collection of modules mechanically fastened together, wired and designed to provide a field-installable unit.

**Photovoltaic Panel System.** A system that incorporates discrete photovoltaic panels, that converts solar radiation into electricity, including rack support systems.

**Photovoltaic Shingles.** A roof covering resembling shingles that incorporates photovoltaic modules.

**Physical Hazard.** A chemical for which there is evidence that it is a combustible liquid, cryogenic fluid, explosive, flammable (solid, liquid or gas), organic peroxide (solid or liquid), oxidizer (solid or liquid), oxidizing gas, pyrophoric (solid, liquid or gas), unstable (reactive) material (solid, liquid or gas) or water-reactive material (solid or liquid).

**Physiological Warning Threshold Level.** A concentration of airborne contaminants, normally expressed in parts per million (ppm) or milligrams per cubic meter (mg/m³), that represents the concentration at which persons can sense the presence of the contaminant due to odor, irritation or other quick-acting physiological response.

**Plastic, Approved.** Any thermoplastic, thermosetting or reinforced thermosetting plastic material that conforms to combustibility classifications specified in the clause applicable to the application and plastic type.

**Plastic Composite.** A generic designation that refers to wood/plastic composites, plastic timber and similar materials.

**Plastic Glazing.** Plastic materials that are glazed or set in a frame or sash.

**Plastic Timber.** A manufactured product made primarily of plastic materials (filled or unfilled) which is generally rectangular in cross clause.

**Platform.** A raised area within a building used for worship, the presentation of music, plays or other entertainment; the head table for special guests; the raised area for lecturers and speakers; boxing and wrestling rings; theater-in-the-round stages; and similar purposes wherein, other than horizontal sliding curtains, there are no overhead hanging curtains, drops, scenery or stage effects other than lighting and sound. A temporary platform is one installed for not more than 30 days.

**Plot.** A portion or parcel of land considered as a unit.

**Plot Line.** A line dividing one plot from another, or from a street or any public place.

**Polypropylene Siding.** A shaped material, made principally from polypropylene homopolymer, or copolymer, which in some cases contains fillers or reinforcements, that is used to clad exterior walls of buildings.

**Porcelain Tile.** Tile that conforms to the requirements of ISO 13007 and for ceramic tile having an absorption of 0.5 percent or less in accordance with ISO 13007.

**Positive Roof Drainage.** The drainage condition in which consideration has been made for all loading deflections of the roof deck, and additional slope has been provided.
to ensure drainage of the roof within 48 hours of precipitation.

**POWER-ASSISTED DOOR.** Swinging door which opens by reduced pushing or pulling force on the door-operating hardware. The door closes automatically after the pushing or pulling force is released and functions with decreased forces. See “Low-energy power-operated door” and “Power-operated door.”

**POWER-OPERATED DOOR.** Swinging, sliding, or folding door which opens automatically when approached by a pedestrian or opens automatically upon an action by a pedestrian. The door closes automatically and includes provisions such as presence sensors to prevent entrapment. See “Low energy power-operated door” and “Power-assisted door.”

**PREFABRICATED WOOD I-JOIST.** Structural member manufactured using sawn or structural composite timber flanges and wood structural panel webs bonded together with exterior exposure adhesives, which forms an “I” cross-clauseal shape.

**PRESTRESSED MASONRY.** Masonry in which internal stresses have been introduced to counteract potential tensile stresses in masonry resulting from applied loads.

**PRIMARY STRUCTURAL FRAME.** The primary structural frame shall include all of the following structural members:

1. The columns.
2. Structural members having direct connections to the columns, including girders, beams, trusses and spandrels.
3. Members of the floor construction and roof construction having direct connections to the columns.
4. Bracing members that are essential to the vertical stability of the primary structural frame under gravity loading shall be considered part of the primary structural frame whether or not the bracing member carries gravity loads.

**PRIVATE GARAGE.** A building or portion of a building in which motor vehicles used by the owner or tenants of the building or buildings on the premises are stored or kept, without provisions for repairing or servicing such vehicles for profit.

**PROSCENIUM WALL.** The wall that separates the stage from the auditorium or assembly seating area.

**PUBLIC ENTRANCE.** An entrance that is not a service entrance or a restricted entrance.

**PUBLIC WAY.** A street, alley or other parcel of land open to the outside air leading to a street, that has been deeded, dedicated or otherwise permanently appropriated to the public for public use and which has a clear width and height of not less than 3048 mm (10 feet).

**PUBLIC-USE AREAS.** Interior or exterior rooms or spaces that are made available to the general public.

**PYROPHORIC.** A chemical with an auto-ignition temperature in air, at or below a temperature of 54.4°C (130°F).

**PYROTECHNIC COMPOSITION.** A chemical mixture that produces visible light displays or sounds through a self-propagating, heat-releasing chemical reaction which is initiated by ignition.

**RADIANT BARRIER.** A material having a low-emittance surface of 0.1 or less installed in building assemblies.

**RAMP.** A walking surface that has a running slope steeper than one unit vertical in 20 units horizontal (5-percent slope).

**RAMP-ACCESS OPEN PARKING GARAGES.** Open parking garages employing a series of continuously rising floors or a series of interconnecting ramps between floors permitting the movement of vehicles under their own power from and to the street level.

**RECORD DRAWINGS.** Drawings (“as built”) that document the location of all devices, appliances, wiring sequences, wiring methods and connections of the components of a fire alarm system as installed.

**REFLECTIVE PLASTIC CORE INSULATION.** An insulation material packaged in rolls, that is less than 12.7 mm ($\frac{1}{2}$ inch) thick, with not less than one exterior low-emittance surface (0.1 or less) and a core material containing voids or cells.

**REGISTERED DESIGN PROFESSIONAL.** An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the
professional registration IEN 310 of the state or jurisdiction in which the project is to be constructed.

REGISTERED DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE. A registered design professional engaged by the owner or the owner’s authorized agent to review and coordinate certain aspects of the project, as determined by the Head of Works, for compatibility with the design of the building or structure, including Submission documents prepared by others, deferred Submission documents and phased Submission documents.

RELIGIOUS WORSHIP, PLACE OF. A building or portion thereof intended for the performance of religious services.

RELOCATABLE BUILDING. A partially or completely assembled building constructed and designed to be reused multiple times and transported to different building sites.

REPAIR. The reconstruction, replacement or renewal of any part of an existing building for the purpose of its maintenance or to correct damage.

REPAIR GARAGE. A building, structure or portion thereof used for servicing or repairing motor vehicles.

REROOFING. The process of recovering or replacing an existing roof covering. See “Roof recover” and “Roof replacement.”

RESIDENTIAL AIRCRAFT HANGAR. An accessory building less than 18 m \(^2\) (62,000 square feet) and 6096 mm (20 feet) in building height constructed on a one- or two-family property where aircraft are stored. Such use will be considered as a residential accessory use incidental to the dwelling.

RESISTANCE FACTOR. A factor that accounts for deviations of the actual strength from the nominal strength and the manner and consequences of failure (also called “strength reduction factor”).

RESTRICTED ENTRANCE. An entrance that is made available for common use on a controlled basis, but not public use, and that is not a service entrance.

RETRACTABLE AWNING. A retractable awning is a cover with a frame that retracts against a building or other structure to which it is entirely supported.

RISK CATEGORY. A categorization of buildings and other structures for determination of flood, wind, snow, ice and earthquake loads based on the risk associated with unacceptable performance.

RISK-TARGETED MAXIMUM CONSIDERED EARTHQUAKE (MCE) GROUND MOTION RESPONSE ACCELERATIONS. The most severe earthquake effects considered by this Code, determined for the orientation that results in the largest maximum response to horizontal ground motions and with adjustment for targeted risk.

ROOF ASSEMBLY (For application to Part 15 only). A system designed to provide weather protection and resistance to design loads. The system consists of a roof covering and roof deck or a single component serving as both the roof covering and the roof deck. A roof assembly can include an underlayment, a thermal barrier, insulation or a vapour retarder.

ROOF COATING. A fluid-applied, adhered coating used for roof maintenance or roof repair, or as a component of a roof covering system or roof assembly.

ROOF COVERING. The covering applied to the roof deck for weather resistance, fire classification or appearance.

ROOF DECK. The flat or sloped surface constructed on top of the exterior walls of a building or other supports for the purpose of enclosing the storey below, or sheltering an area, to protect it from the elements, not including its supporting members or vertical supports.

ROOF RECOVER. The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering.

ROOF REPAIR. Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance.

ROOF REPLACEMENT. The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.

ROOF VENTILATION. The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from,
attics, cathedral ceilings or other enclosed spaces over which a roof assembly is installed.

**ROOFTOP STRUCTURE.** A structure erected on top of the roof deck or on top of any part of a building.

**RUNNING BOND.** The placement of masonry units such that head joints in successive courses are horizontally offset at least one-quarter the unit length.

**SALLYPORT.** A security vestibule with two or more doors or gates where the intended purpose is to prevent continuous and unobstructed passage by allowing the release of only one door or gate at a time.

**SCISSOR STAIRWAY.** Two interlocking stairways providing two separate paths of escape located within one exit enclosure.

**SCUPPER.** An opening in a wall or parapet that allows water to drain from a roof.

**SECONDARY MEMBERS.** The following structural members shall be considered secondary members and not part of the primary structural frame:

1. Structural members not having direct connections to the columns.
2. Members of the floor construction and roof construction not having direct connections to the columns.
3. Bracing members other than those that are part of the primary structural frame.

**SEISMIC DESIGN CATEGORY.** A classification assigned to a structure based on its risk category and the severity of the design earthquake ground motion at the site.

**SEISMIC FORCE-RESISTING SYSTEM.** That part of the structural system that has been considered in the design to provide the required resistance to the prescribed seismic forces.

**SELF-CLOSING.** As applied to a fire door or other opening protective, means equipped with an device that will ensure closing after having been opened.

**SELF-LUMINOUS.** Illuminated by a self-contained power source, other than batteries, and operated independently of external power sources.

**SELF-SERVICE STORAGE FACILITY.** Real property designed and used for the purpose of renting or leasing individual storage spaces to customers for the purpose of storing and removing personal property on a self-service basis.

**SERVICE CORRIDOR.** A fully enclosed passage used for transporting HPM and purposes other than required means of escape.

**SERVICE ENTRANCE.** An entrance intended primarily for delivery of goods or services.

**SHAFT.** An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and roof.

**SHAFT ENCLOSURE.** The walls or construction forming the boundaries of a shaft.

**SHALLOW FOUNDATION.** A shallow foundation is an individual or strip footing, a mat foundation, a slab-on-grade foundation or a similar foundation element.

**SHEAR WALL** (for Part 23). A wall designed to resist lateral forces parallel to the plane of a wall.

Shear wall, perforated. A wood structural panel sheathed wall with openings, that has not been specifically designed and detailed for force transfer around openings.

Shear wall segment, perforated. A clause of shear wall with full-height sheathing that meets the height-to-width ratio limits of Clause 4.3.4 of AWC SDPWS.

**SHINGLE FASHION.** A method of installing roof or wall coverings, water-resistive barriers, flashing or other building components such that upper layers of material are placed overlapping lower layers of material to provide for drainage via gravity and moisture control.

**SINGLE-PLY MEMBRANE.** A roofing membrane that is field applied using one layer of membrane material (either homogeneous or composite) rather than multiple layers.

**SINGLE-STATION SMOKE ALARM.** An assembly incorporating the detector, the control equipment and the alarm-sounding device in one unit, operated from a power supply either in the unit or obtained at the point of installation.
SITE. A parcel of land bounded by a plot line or a designated portion of a public right-of-way.

SKYLIGHT, UNIT. A factory-assembled, glazed fenestration unit, containing one panel of glazing material that allows for natural lighting through an opening in the roof assembly while preserving the weather-resistant barrier of the roof.

SKYLIGHTS AND SLOPED GLAZING. Glass or other transparent or translucent glazing material installed at a slope of 15 degrees (0.26 rad) or more from vertical. Unit skylights, tubular daylighting devices, glazing materials, solariums, sunrooms, roofs and sloped walls are included in this definition.

SLEEPING UNIT. A single unit that provides rooms or spaces for one or more persons, includes permanent provisions for sleeping and can include provisions for living, eating and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a dwelling unit are not sleeping units.

SMOKE ALARM. A single- or multiple-station alarm responsive to smoke. See “Multiple-station smoke alarm” and “Single-station smoke alarm.”

SMOKE BARRIER. A continuous membrane, either vertical or horizontal, such as a wall, floor or ceiling assembly, that is designed and constructed to restrict the movement of smoke.

SMOKE COMPARTMENT. A space within a building enclosed by smoke barriers on all sides, including the top and bottom.

SMOKE DAMPER. A listed device installed in ducts and air transfer openings designed to resist the passage of smoke. The device is installed to operate automatically, controlled by a smoke detection system, and where required, is capable of being positioned from a fire command center.

SMOKE DETECTOR. A listed device that senses visible or invisible particles of combustion.

SMOKE PARTITION. A wall assembly that extends from the top of the foundation or floor below to the underside of the floor or roof sheathing, deck or slab above or to the underside of the ceiling above where the ceiling membrane is constructed to limit the transfer of smoke.

SMOKE-DEVELOPED INDEX. A comparative measure, expressed as a dimensionless number, derived from measurements of smoke obscuration versus time for a material tested in accordance with ASTM E84.

SMOKEPROOF ENCLOSURE. An exit stairway or ramp designed and constructed so that the movement of the products of combustion produced by a fire occurring in any part of the building into the enclosure is limited.

SMOKE-PROTECTED ASSEMBLY SEATING. Seating served by means of escape that is not subject to smoke accumulation within or under a structure for a specified design time by means of passive design or by mechanical ventilation.

SOFT CONTAINED PLAY EQUIPMENT STRUCTURE. A children’s play structure containing one or more components where the user enters a play environment that utilizes pliable materials.

SOLID. A material that has a melting point, decomposes or sublimes at a temperature greater than 20°C (68°F).

SPECIAL AMUSEMENT BUILDING. A special amusement building is any temporary or permanent building or portion thereof that is occupied for amusement, entertainment or educational purposes and that contains a device or system that conveys passengers or provides a walkway along, around or over a course in any direction so arranged that the means of escape path is not readily apparent due to visual or audio distractions or is intentionally confounded or is not readily available because of the nature of the attraction or mode of conveyance through the building or structure.

SPECIAL INSPECTION. Inspection of construction requiring the expertise of an approved special inspector in order to ensure compliance with this Code and the approved construction documents.

Continuous special inspection. Special inspection by the special inspector who is present continuously when and where the work to be inspected is being performed.

Periodic special inspection. Special inspection by the special inspector who is intermittently present where the work to be inspected has been or is being performed.
SPECIAL INSPECTOR. A qualified person employed or retained by an approved agency and approved by the Head of Works as having the competence necessary to inspect a particular type of construction requiring special inspection.

SPECIFIED COMPRRESSIVE STRENGTH OF MASONRY, f’m. Minimum compressive strength, expressed as force per unit of net cross-clauseal area, required of the masonry used in construction by the approved construction documents, and upon which the project design is based. Whenever the quantity f’ is under the radical sign, the square root of m numerical value only is intended and the result has units of pounds per square inch (psi) (MPa).

SPICE. The result of a factory and/or field method of joining or connecting two or more lengths of a fire-resistant joint system into a continuous entity.

SPRAY ROOM. A room designed to accommodate spraying operations.

SPRAYED FIRE-RESISTANT MATERIALS. Cementitious or fibrous materials that are sprayed to provide fire-resistant protection of the substrates.

STAGE. A space within a building utilized for entertainment or presentations, which includes overhead hanging curtains, drops, scenery or stage effects other than lighting and sound.

STAIR. A change in elevation, consisting of one or more risers.

STAIRWAY. One or more flights of stairs, either exterior or interior, with the necessary landings and platforms connecting them, to form a continuous and uninterrupted passage from one level to another.

STAIRWAY, SPIRAL. A stairway having a closed circular form in its plan view with uniform clause-shaped treads attached to and radiating from a minimum-diameter supporting column.

STANDBY POWER SYSTEM. A source of automatic electric power of a required capacity and duration to operate required building, hazardous materials or ventilation systems in the event of a failure of the primary power. Standby power systems are required for electrical loads where interruption of the primary power could create hazards or hamper rescue or fire-fighting operations.

START OF CONSTRUCTION. The date of permit issuance for new construction and substantial improvements to existing structures, provided the actual start of construction, repair, reconstruction, rehabilitation, addition, placement or other improvement is within 180 days after the date of issuance. The actual start of construction means the first placement of permanent construction of a building (including a manufactured home) on a site, such as the pouring of a slab or footings, installation of pilings or construction of columns.

STEEL CONSTRUCTION, COLD-FORMED. That type of construction made up entirely or in part of steel structural members cold formed to shape from sheet or strip steel such as roof deck, floor and wall panels, studs, floor joists, roof joists and other structural elements.

STEEL ELEMENT, STRUCTURAL. Any steel structural member of a building or structure consisting of rolled shapes, pipe, hollow structural clauses, plates, bars, sheets, rods or steel castings other than cold-formed steel or steel joist members.

STEEL JOIST. Any steel structural member of a building or structure made of hot-rolled or cold-formed solid or open-web clauses, or riveted or welded bars, strip or sheet steel members, or splotted and expanded, or otherwise deformed rolled clauses.

STEEP SLOPE. A roof slope greater than two units vertical in 12 units horizontal (17-percent slope).

STONE MASONRY. Masonry composed of field, quarried or cast stone units bonded by mortar.

STORAGE, HAZARDOUS MATERIALS. The keeping, retention or leaving of hazardous materials in closed containers, tanks, cylinders, or similar vessels; or vessels supplying operations through closed connections to the vessel.

STORAGE RACKS. Cold-formed or hot-rolled steel structural members which are formed into steel storage racks, including pallet storage racks, movable-shelf racks, rack-supported systems, automated storage and retrieval systems (stacker racks), push-back racks, pallet-flow racks, case-flow racks, pick modules and rack-supported platforms. Other types of racks, such as drive-in or drive-through racks, cantilever racks, portable racks or racks made of materials other than steel, are not
considered storage racks for the purpose of this Code.

**STORM SHELTER.** A building, structure or portions thereof, constructed in accordance with this Code and designated for use during a severe wind storm event.

**Community storm shelter.** A storm shelter not defined as a “Residential storm shelter.”

**Residential storm shelter.** A storm shelter serving occupants of dwelling units and having an occupant load not exceeding 16 persons.

**STOREY.** That portion of a building included between the upper surface of a floor and the upper surface of the floor or roof next above (see “Basement,” “Building height,” “Grade plane” and “Mezzanine”). A storey is measured as the vertical distance from top to top of two successive tiers of beams or finished floor surfaces and, for the topmost storey, from the top of the floor finish to the top of the ceiling joists or, where there is not a ceiling, to the top of the roof rafters.

**STOREY ABOVE GRADE PLANE.** Any storey having its finished floor surface entirely above grade plane, or in which the finished surface of the floor next above is:

1. More than 1829 mm (6 feet) above grade plane; or
2. More than 3658 mm (12 feet) above the finished ground level at any point.

**STRUCTURAL COMPOSITE TIMBER.** Structural member manufactured using wood elements bonded together with exterior adhesives. Examples of structural composite timber are:

**Laminated strand timber (LST).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 0.10 inch (2.54 mm) or less and their average lengths not less than 150 times the least dimension of the wood strand elements.

**Laminated veneer timber (LVT).** A composite of wood veneer sheet elements with wood fibers primarily oriented along the length of the member, where the veneer element thicknesses are 6.4 mm (0.25 inches) or less.

**Oriented strand timber (OST).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member, where the least dimension of the wood strand elements is 2.54 mm (0.10 inches) or less and their average lengths not less than 75 times and less than 150 times the least dimension of the strand elements.

**Parallel strand timber (PST).** A composite of wood strand elements with wood fibers primarily oriented along the length of the member where the least dimension of the wood strand elements is 6.4 mm (0.25 inches) or less and their average lengths not less than 300 times the least dimension of the wood strand elements.

**STRUCTURAL GLUED-LAMINATED TIMBER.** An engineered, stress-rated product of a timber laminating plant, comprised of assemblies of specially selected and prepared wood laminations in which the grain of all laminations is approximately parallel longitudinally and the laminations are bonded with adhesives.

**STRUCTURAL OBSERVATION.** The visual observation of the structural system by a registered design professional for general conformance to the approved construction documents.

**STRUCTURE.** That which is built or constructed.

**SUBSTANTIAL DAMAGE.** Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

**SUBSTANTIAL IMPROVEMENT.** Any repair, reconstruction, rehabilitation, alteration, addition or other improvement of a building or structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the improvement or repair is started. If the structure has sustained substantial damage, any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include either:

1. Any project for improvement of a building required to correct existing
health, sanitary or safety Code violations identified by the Head of Works and that are the minimum necessary to assure safe living conditions.

2. Any alteration of a historic structure provided that the alteration will not preclude the structure’s continued designation as a historic structure.

SUPERVISING STATION. A facility that receives signals and at which personnel are in attendance at all times to respond to these signals.

SUPERVISORY SERVICE. The service required to monitor performance of guard tours and the operative condition of fixed suppression systems or other systems for the protection of life and property.

SUPERVISORY SIGNAL. A signal indicating the need of action in connection with the supervision of guard tours, the fire suppression systems or equipment or the maintenance features of related systems.

SUPERVISORY SIGNAL-INITIATING DEVICE. An initiation device, such as a valve supervisory switch, water-level indicator or low-air pressure switch on a dry-pipe sprinkler system, whose change of state signals an off-normal condition and its restoration to normal of a fire protection or life safety system, or a need for action in connection with guard tours, fire suppression systems or equipment or maintenance features of related systems.

SUSCEPTIBLE BAY. A roof or portion thereof with either of the following:

1. A slope less than \( \frac{1}{4} \) -inch per foot (0.0208 rad).

2. On which water is impounded, in whole or in part, and the secondary drainage system is functional but the primary drainage system is blocked.

A roof surface with a slope of \( \frac{1}{4} \) -inch per foot (0.0208 rad) or greater towards points of free drainage is not a susceptible bay.

SWIMMING POOL. Any structure intended for swimming, recreational bathing or wading that contains water over 610 mm (24 inches) deep. This includes in-ground, above-ground and on-ground pools; hot tubs; spas and fixed-in-place wading pools.

TECHNICAL PRODUCTION AREA. Open elevated areas or spaces intended for entertainment technicians to walk on and occupy for servicing and operating entertainment technology systems and equipment. Galleries, including fly and lighting galleries, gridirons, catwalks, and similar areas are designed for these purposes.

TENSILE MEMBRANE STRUCTURE. A membrane structure having a shape that is determined by tension in the membrane and the geometry of the support structure. Typically, the structure consists of both flexible elements (e.g., membrane and cables), nonflexible elements (e.g., struts, masts, beams and arches) and the anchorage (e.g., supports and foundations). This includes frame-supported tensile membrane structures.

TENT. A structure, enclosure, umbrella structure or shelter, with or without sidewalls or drops, constructed of fabric or pliable material supported in any manner except by air or the contents it protects (see “Umbrella structure”).

THERMAL ISOLATION. A separation of conditioned spaces, between a sunroom and a dwelling unit, consisting of existing or new walls, doors or windows.

THERMOPLASTIC MATERIAL. A plastic material that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

THERMOSETTING MATERIAL. A plastic material that is capable of being changed into a substantially nonreformable product when cured.

THROUGH PENETRATION. A breach in both sides of a floor, floor-ceiling or wall assembly to accommodate an item passing through the breaches.

THROUGH-PENETRATION FIRESTOP SYSTEM. An assemblage consisting of a fire-resistance-rated floor, floor-ceiling, or wall assembly, one or more penetrating items passing through the breaches in both sides of the assembly and the materials or devices, or both, installed to resist the spread of fire through the assembly for a prescribed period of time.
TIE, WALL. Metal connector that connects wythes of masonry walls together.

TIE-DOWN (HOLD-DOWN). A device used to resist uplift of the chords of shear walls.

TILE, STRUCTURAL CLAY. A hollow masonry unit composed of burned clay, shale, fire clay or mixture thereof, and having parallel cells.

TIRES, BULK STORAGE OF. Storage of tires where the area available for storage exceeds 3\textsuperscript{2} 20,000 cubic feet (566 m\textsuperscript{3}).

TOWNHOUSE. A single-family dwelling unit constructed in a group of three or more attached units in which each unit extends from the foundation to roof and with open space on at least two sides.

TOXIC. A chemical falling within any of the following categories:

1. A chemical that has a median lethal dose (LD\textsubscript{50}) of more than 50 milligrams per kilogram, but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

2. A chemical that has a median lethal dose (LD\textsubscript{50}) of more than 200 milligrams per kilogram, but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.

3. A chemical that has a median lethal concentration (LC\textsubscript{50}) in air of more than 50 parts per million, but not more than 2,000 parts per million by volume of gas or vapour, or more than 2 milligrams per liter but not more than 20 milligrams per liter of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

TRANSIENT. Occupancy of a dwelling unit or sleeping unit for not more than 30 days.

TRANSIENT AIRCRAFT. Aircraft based at another location and that is at the transient location for not more than 90 days.

TREATED WOOD. Wood products that are conditioned to enhance fire-retardant or preservative properties.

Fire-retardant-treated wood. Wood products that, when impregnated with chemicals by a pressure process or other means during manufacture, exhibit reduced surface-burning characteristics and resist propagation of fire.

Preservative-treated wood. Wood products that, conditioned with chemicals by a pressure process or other means, exhibit reduced susceptibility to damage by fungi, insects or marine borers.

TRIM. Picture molds, chair rails, baseboards, handrails, door and window frames and similar decorative or protective materials used in fixed applications.

TROUBLE SIGNAL. A signal initiated by the fire alarm system or device indicative of a fault in a monitored circuit or component.

TUBULAR DAYLIGHTING DEVICE (TDD). A non-operable fenestration unit primarily designed to transmit daylight from a roof surface to an interior ceiling via a tubular conduit. The basic unit consists of an exterior glazed weathering surface, a light-transmitting tube with a reflective interior surface, and an interior-sealing device such as a translucent ceiling panel. The unit can be factory assembled, or field-assembled from a manufactured kit.

UMBRELLA STRUCTURE. A structure, enclosure or shelter with or without sidewalls or drops, constructed of fabric or pliable material supported by a central pole or poles (see “Tent”).

UNDERLAYERMENT. One or more layers of a material that is applied to a steep-slope roof covering deck under the roof covering and resists liquid water that penetrates the roof covering.

UNSTABLE (REACTIVE) MATERIAL. A material, other than an explosive, which in the pure state or as commercially produced, will vigorously polymerize, decompose, condense or become self-reactive and undergo other violent chemical changes, including explosion, when exposed to heat, friction or shock, or in
the absence of an inhibitor, or in the presence of contaminants, or in contact with incompatible materials. Unstable (reactive) materials are subdivided as follows:

**Class 4.** Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures. This class includes materials that are sensitive to mechanical or localized thermal shock at normal temperatures and pressures.

**Class 3.** Materials that in themselves are capable of detonation or of explosive decomposition or explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. This class includes materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures.

**Class 2.** Materials that in themselves are normally unstable and readily undergo violent chemical change but do not detonate. This class includes materials that can undergo chemical change with rapid release of energy at normal temperatures and pressures, and that can undergo violent chemical change at elevated temperatures and pressures.

**Class 1.** Materials that in themselves are normally stable but which can become unstable at elevated temperatures and pressure.

**VAPOUR PERMEABLE.** The property of having a moisture vapour permeance rating of
\[10^{-5} \text{ perms} \ (2.9 \times 10^{-12} \text{ kg/Pa} \times \text{s} \times \text{m}^2)\] or greater, when tested in accordance with the desiccant method using Procedure A of ASTM E96. A vapour permeable material permits the passage of moisture vapour.

**VAPOUR RETARDER CLASS.** A measure of a material or assembly's ability to limit the amount of moisture that passes through that material or assembly. Vapour retarder class shall be defined using the desiccant method with Procedure A of ASTM E96 as follows:

**Class I:** 0.1 perm or less.

**Class II:** 0.1 < perm ≤ 1.0 perm.

**Class III:** 1.0 < perm ≤ 10 perm.

**VEGETATIVE ROOF.** An assembly of interacting components designed to waterproof a building's top surface that includes, by design, vegetation and related landscape elements.

**VEHICLE BARRIER.** A component or a system of components, near open sides or walls of garage floors or ramps that act as a restraint for vehicles.

**VEHICULAR GATE.** A gate that is intended for use at a vehicular entrance or exit to a facility, building or portion thereof, and that is not intended for use by pedestrian traffic.

**VENEER.** A facing attached to a wall for the purpose of providing ornamentation, protection or insulation, but not counted as adding strength to the wall.

**VENTILATION.** The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from, any space.

**VINYL SIDING.** A shaped material, made principally from rigid polyvinyl chloride (PVC), that is used as an exterior wall covering.

**VISIBLE ALARM NOTIFICATION APPLIANCE.** A notification appliance that alerts by the sense of sight.

**WALKWAY, PEDESTRIAN.** A walkway used exclusively as a pedestrian trafficway.

**WALL (for Part 22).** A vertical element with a horizontal length-to-thickness ratio greater than three, used to enclose space.

**Cavity wall.** A wall built of masonry units or of concrete, or a combination of these materials, arranged to provide an airspace within the wall, and in which the inner and outer parts of the wall are tied together with metal ties.

**Dry-stacked, surface-bonded wall.** A wall built of concrete masonry units where the units are stacked dry, without mortar on the bed or head joints, and where both sides of the wall are coated with a surface-bonding mortar.

**Parapet wall.** The part of any wall entirely above the roof line.

**WALL, LOAD-BEARING.** Any wall meeting either of the following classifications:

1. Any metal or wood stud wall that supports more than 100 pounds per
linear foot (1459 N/m) of vertical load in addition to its own weight.

2. Any masonry or concrete wall that supports more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight.

WALL, NONLOAD-BEARING. Any wall that is not a load-bearing wall.

WATER-REACTIVE MATERIAL. A material that explodes; violently reacts; produces flammable, toxic or other hazardous gases; or evolves enough heat to cause autoignition or ignition of combustibles upon exposure to water or moisture. Water-reactive materials are subdivided as follows:

   Class 3. Materials that react explosively with water without requiring heat or confinement.
   Class 2. Materials that react violently with water or have the ability to boil water. Materials that produce flammable, toxic or other hazardous gases or evolve enough heat to cause autoignition or ignition of combustibles upon exposure to water or moisture.
   Class 1. Materials that react with water with some release of energy, but not violently.

WATER-RESISTIVE BARRIER. A material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior covering from further intruding into the exterior wall assembly.

WEATHER-EXPOSED SURFACES. Surfaces of walls, ceilings, floors, roofs, soffits and similar surfaces exposed to the weather except the following:

1. Ceilings and roof soffits enclosed by walls, fascia, bulkheads or beams that extend not less than 305 mm (12 inches) below such ceiling or roof soffits.
2. Walls or portions of walls beneath an unenclosed roof area, where located a horizontal distance from an open exterior opening equal to not less than twice the height of the opening.
3. Ceiling and roof soffits located a minimum horizontal distance of 3048 mm (10 feet) from the outer edges of the ceiling or roof soffits.

WET-CHEMICAL EXTINGUISHING SYSTEM. A solution of water and potassium-carbonate-based chemical, potassium-acetate-based chemical or a combination thereof, forming an extinguishing agent.

WHEELCHAIR SPACE. A space for a single wheelchair and its occupant.

WINDER. A tread with nonparallel edges.

WIRE BACKING. Horizontal strands of tautened wire attached to surfaces of vertical supports which, when covered with the building paper, provide a backing for cement plaster.

WIRELESS PROTECTION SYSTEM. A system or a part of a system that can transmit and receive signals without the aid of wire.

WOOD/PLASTIC COMPOSITE. A composite material made primarily from wood or cellulose-based materials and plastic.

WOOD SHEAR PANEL. A wood floor, roof or wall component sheathed to act as a shear wall or diaphragm.

WOOD STRUCTURAL PANEL. A panel manufactured from veneers, wood strands or wafers or a combination of veneer and wood strands or wafers bonded together with waterproof synthetic resins or other suitable bonding systems. Examples of wood structural panels are:

   Composite panels. A wood structural panel that is comprised of wood veneer and reconstituted wood-based material and bonded together with waterproof adhesive.

Oriented strand board (OSB). A mat-formed wood structural panel comprised of thin rectangular wood strands arranged in cross-aligned layers with surface layers normally arranged in the long panel direction and bonded with waterproof adhesive.

Plywood. A wood structural panel comprised of plies of wood veneer arranged in cross-aligned layers. The plies are bonded with waterproof adhesive that cures on application of heat and pressure.

WORKSTATION. A defined space or an independent principal piece of equipment using HPM within a fabrication area where a specific function, laboratory procedure or research activity occurs. Approved or listed hazardous
materials storage cabinets, flammable liquid storage cabinets or gas cabinets serving a workstation are included as part of the workstation. A workstation is allowed to contain ventilation equipment, fire protection devices, detection devices, electrical devices and other processing and scientific equipment.

**WYTHE.** Each continuous, vertical clause of a wall, one masonry unit in thickness.

**YARD.** An open space, other than a court, unobstructed from the ground to the sky, except where specifically provided by this Code, on the plot on which a building is situated.

**ZONE.** A defined area within the protected premises. A zone can define an area from which a signal can be received, an area to which a signal can be sent or an area in which a form of control can be executed.

**ZONE, NOTIFICATION.** An area within a building or facility covered by notification appliances which are activated simultaneously.
PART 3: OCCUPANCY CLASSIFICATION AND USE

User note:
About this part: Part 3 provides the criteria by which buildings and structures are classified into use groups and occupancies. Through the balance of the Code, occupancy classification is fundamental in the setting of features of construction; occupant safety requirements, especially building limitations; means of escape; fire protection systems; and interior finishes.

3.1 SCOPE

3.1.1 General.
The provisions of this part shall control the classification of all buildings and structures as to occupancy and use. Different classifications of occupancy and use represent varying levels of hazard and risk to building occupants and adjacent properties.

3.2 OCCUPANCY CLASSIFICATION AND USE DESIGNATION

3.2.1 Occupancy classification.
Occupancy classification is the formal designation of the primary purpose of the building, structure or portion thereof. Structures shall be classified into one or more of the occupancy groups listed in this clause based on the nature of the hazards and risks to building occupants generally associated with the intended purpose of the building or structure. An area, room or space that is intended to be occupied at different times for different purposes shall comply with all applicable requirements associated with such potential multipurpose. Structures containing multiple occupancy groups shall comply with this Code. Where a structure is proposed for a purpose that is not specifically listed in this clause, such structure shall be classified in the occupancy it most nearly resembles based on the fire safety and relative hazard. Occupied roofs shall be classified in the group that the occupancy most nearly resembles, according to the fire safety and relative hazard, and shall comply with this Code.

2. Business Clause 3.4 Group B.
3. Educational Clause 3.5 Group E.
7. Mercantile Clause 3.9 Group M.
10. Utility and Miscellaneous Clause 3.12 Group U.

3.2.2 Use designation.
Occupancy groups contain subordinate uses having similar hazards and risks to building occupants. Uses include, but are not limited to, those functional designations listed within the occupancy group descriptions in Clause 3.2.1. Certain uses require specific limitations and controls in accordance with the provisions of part 4 and else where in this Code.

3.3 ASSEMBLY GROUP A

3.3.1 Assembly Group A.
Assembly Group A occupancy includes, among others, the use of a building or structure, or a portion thereof, for the gathering of persons for purposes such as civic, social or religious functions; recreation, food or drink consumption or awaiting transportation.

3.3.1.1 Small buildings and tenant spaces.
A building or tenant space used for assembly purposes with an occupant load of less than 50 persons shall be classified as a Group B occupancy.

3.3.1.2 Small assembly spaces.
The following rooms and spaces shall not be classified as Assembly occupancies:

1. A room or space used for assembly purposes with an occupant load of less than 50 persons and accessory to another occupancy shall be classified as a Group B
occupancy or as part of that occupancy.

2. A room or space used for assembly purposes that is less than 70 m² (750 square feet) in area and accessory to another occupancy shall be classified as a Group B occupancy or as part of that occupancy.

3.3.1.3 Associated with Group E occupancies.
A room or space used for assembly purposes that is associated with a Group E occupancy is not considered a separate occupancy.

3.3.1.4 Accessory to places of religious worship.
Accessory religious educational rooms and religious auditoriums with occupant loads of less than 100 per room or space are not considered separate occupancies.

3.3.2 Assembly Group A-1.
Group A-1 occupancy includes assembly uses, usually with fixed seating, intended for the production and viewing of the performing arts or motion pictures including, but not limited to:

- Motion picture theaters
- Symphony and concert halls
- Television and radio studios admitting an audience
- Theaters

3.3.3 Assembly Group A-2.
Group A-2 occupancy includes assembly uses intended for food and/or drink consumption including, but not limited to:

- Banquet halls
- Casinos (gaming areas)
- Nightclubs
- Restaurants, cafeterias and similar dining facilities (including associated commercial kitchens)
- Taverns and bars

3.3.4 Assembly Group A-3.
Group A-3 occupancy includes assembly uses intended for worship, recreation or amusement and other assembly uses not classified elsewhere in Group A including, but not limited to:

- Amusement arcades
- Art galleries
- Bowling alleys
- Community halls
- Courtrooms
- Dance halls (not including food or drink consumption)
- Exhibition halls
- Funeral parlors
- Greenhouses for the conservation and exhibition of plants that provide public access.
- Gymnasiums (without spectator seating)
- Indoor swimming pools (without spectator seating)
- Indoor tennis courts (without spectator seating)
- Lecture halls
- Libraries
- Museums
- Places of religious worship
- Pool and billiard parlors
- Waiting areas in transportation terminals

3.3.5 Assembly Group A-4.
Group A-4 occupancy includes assembly uses intended for viewing of indoor sporting events and activities with spectator seating including, but not limited to:

- Arenas
- Skating rinks
- Swimming pools
- Tennis courts

3.3.6 Assembly Group A-5.
Group A-5 occupancy includes assembly uses intended for participation in or viewing outdoor activities including, but not limited to:

- Amusement park structures
- Bleachers
- Grandstands
- Stadiums

3.4 BUSINESS GROUP B

3.4.1 Business Group B.
Business Group B occupancy includes, among others, the use of a building or structure, or a portion thereof, for office, professional or service-type transactions, including storage of records and accounts. Business occupancies shall include, but not be limited to, the following:

- Airport traffic control towers
- Ambulatory care facilities
- Animal hospitals, kennels and pounds
- Banks
- Barber and beauty shops
- Car wash
- Civic administration
- Clinic, outpatient
Dry cleaning and laundries: pick-up and delivery stations and self-service.
Educational occupancies for students above the 12th grade.
Electronic data processing
Food processing establishments and commercial kitchens not associated with restaurants, cafeterias and similar dining facilities not more than 232 m² (2,500 square feet) in area.
Laboratories: testing and research
Motor vehicle showrooms
Post offices
Print shops
Professional services (architects, attorneys, dentists, physicians, engineers, etc.).
Radio and television stations
Telephone exchanges
Training and skill development not in a school or academic program (this shall include, but not be limited to, tutoring centers, martial arts studios, gymnastics and similar uses regardless of the ages served, and where not classified as a Group A occupancy).

3.5 EDUCATIONAL GROUP E

3.5.1 Educational Group E.
Educational Group E occupancy includes, among others, the use of a building or structure, or a portion thereof, by six or more persons at any one time for educational purposes through the 12th grade.

3.5.2 Accessory to places of religious worship.
Religious educational rooms and religious auditoriums, which are accessory to places of religious worship in accordance with Clause 3.3.1.4 and have occupant loads of less than 100 per room or space, shall be classified as Group A-3 occupancies.

3.5.2.2 Five or fewer children.
A facility having five or fewer children receiving such day care shall be classified as part of the primary occupancy.

3.5.2.3 Five or fewer children in a dwelling unit.
A facility such as the above within a dwelling unit and having five or fewer children receiving such day care shall be classified as a Group R-3 occupancy or shall comply with this Code.

3.6 FACTORY GROUP F

3.6.1 Factory Industrial Group F.
Factory Industrial Group F occupancy includes, among others, the use of a building or structure, or a portion thereof, for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operations that are not classified as a Group H hazardous or Group S storage occupancy.

3.6.2 Moderate-hazard factory industrial, Group F-1.
Factory industrial uses that are not classified as Factory Industrial F-2 Low Hazard shall be classified as F-1 Moderate Hazard and shall include, but not be limited to, the following:

- Aircraft (manufacturing, not to include repair)
- Appliances
- Athletic equipment
- Automobiles and other motor vehicles
- Bakeries
- Beverages: over 16-percent alcohol content
- Bicycles
- Boats
- Brooms or brushes
- Business machines
- Cameras and photo equipment
- Canvas or similar fabric
- Carpets and rugs (includes cleaning)
- Clothing
- Construction and agricultural machinery
- Disinfectants
- Dry cleaning and dyeing
- Electric generation plants
- Electronics
- Engines (including rebuilding)
- Food processing establishments and commercial kitchens not associated with restaurants, cafeterias and similar dining facilities more than 232 m² (2,500 square feet) in area.
- Furniture
- Hemp products
Jute products
Laundries
Leather products
Machinery
Metals
Millwork (sash and door)
Motion pictures and television filming (without spectators)
Musical instruments
Optical goods
Paper mills or products
Photographic film
Plastic products
Printing or publishing
Recreational vehicles
Refuse incineration
Shoes
Soaps and detergents
Textiles
Tobacco
Trailers
Upholstering
Wood; distillation
Woodworking (cabinet)

3.6.3 Low-hazard factory industrial, Group F-2.

Factory industrial uses that involve the fabrication or manufacturing of noncombustible materials that during finishing, packing or processing do not involve a significant fire hazard shall be classified as F-2 occupancies and shall include, but not be limited to, the following:

- Beverages: up to and including 16-percent alcohol content
- Brick and masonry
- Ceramic products
- Foundries
- Glass products
- Gypsum
- Ice
- Metal products (fabrication and assembly)

3.7 HIGH-HAZARD GROUP H

3.7.1 High-hazard Group H.

High-hazard Group H occupancy includes, among others, the use of a building or structure, or a portion thereof, that involves the manufacturing, processing, generation or storage of materials that constitute a physical or health hazard in quantities in excess of those allowed in control areas complying with this Code based on the maximum allowable quantity limits for control areas set forth in

Tables 3.1.1(1) and 3.7.1(2). Hazardous occupancies are classified in Groups H-1, H-2, H-3, H-4 and H-5 and shall be in accordance with this clause, the requirements of this Code and the Ghana Fire Code. Hazardous materials stored, or used on top of roofs or canopies, shall be classified as outdoor storage or use and shall comply with the Ghana Fire Code.
### TABLE 3.7.1(1): MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARD

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CLASS</th>
<th>GROUP WHEN THE MAXIMUM ALLOWABLE QUANTITY IS EXCEEDED</th>
<th>STORAGE&lt;sup&gt;a&lt;/sup&gt;</th>
<th>USE-CLOSED SYSTEMS&lt;sup&gt;a&lt;/sup&gt;</th>
<th>USE-OPEN SYSTEMS&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustible dust</td>
<td>NA</td>
<td>H-2</td>
<td>See Note q</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Combustible fiber&lt;sup&gt;g&lt;/sup&gt;</td>
<td>H-3</td>
<td>(100) (1,000)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Combustible liquid&lt;sup&gt;hl&lt;/sup&gt;</td>
<td>IIIA</td>
<td>H-2 or H-3</td>
<td>NA</td>
<td>120&lt;sup&gt;E&lt;/sup&gt;</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>IIIB</td>
<td>H-2 or H-3</td>
<td>NA</td>
<td>330&lt;sup&gt;h&lt;/sup&gt;</td>
<td>NA</td>
</tr>
<tr>
<td>Cryogenic flammable</td>
<td>NA</td>
<td>H-2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cryogenic inert</td>
<td>NA</td>
<td>H-2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cryogenic oxidizing</td>
<td>NA</td>
<td>H-3</td>
<td>NA</td>
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</table>

**Explosives**

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>GROUP</th>
<th>CLASS</th>
<th>MAXIMUM ALLOWABLE QUANTITY (cubic feet)</th>
<th>LIQUID (gallons) (pounds)</th>
<th>GAS CUBIC FEET AT NTP</th>
<th>SOLID POUNDS</th>
<th>LIQUID (gallons) (pounds)</th>
<th>GAS CUBIC FEET AT NTP</th>
<th>SOLID POUNDS</th>
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<tbody>
<tr>
<td>Division 1.1</td>
<td>I</td>
<td>H-1</td>
<td>1&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
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<td>II</td>
<td>H-1</td>
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<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Division 1.4</td>
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<td>Division 1.6</td>
<td>H-1</td>
<td>1&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Division 1.4G</td>
<td>Division 1.4G</td>
<td>H-1</td>
<td>1&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Division 1.5G</td>
<td>Division 1.5G</td>
<td>H-1</td>
<td>1&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

**Flammable gas**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>CLASS</th>
<th>MAXIMUM ALLOWABLE QUANTITY (cubic feet)</th>
<th>LIQUID (gallons) (pounds)</th>
<th>GAS CUBIC FEET AT NTP</th>
<th>SOLID POUNDS</th>
<th>LIQUID (gallons) (pounds)</th>
<th>GAS CUBIC FEET AT NTP</th>
<th>SOLID POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Liquefied</td>
<td>H-2</td>
<td>(150)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
<td>(150)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>IB</td>
<td>or IC</td>
<td>H-2 or H-3</td>
<td>120&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
<td>120&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NA</td>
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</tr>
</tbody>
</table>

(Continued)
### TABLE 3.7.1(1)—continued: MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARD

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CLASS</th>
<th>GROUP WHEN THE MAXIMUM ALLOWABLE QUANTITY IS EXCEEDED</th>
<th>STORAGE&lt;sup&gt;a&lt;/sup&gt;</th>
<th>USE-CLOSED SYSTEMS&lt;sup&gt;b&lt;/sup&gt;</th>
<th>USE-OPEN SYSTEMS&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Solid pounds (cubic feet)</td>
<td>Liquid pounds (pounds)</td>
<td>Gas cubic feet at NTP</td>
<td>Solid pounds (cubic feet)</td>
</tr>
<tr>
<td>Flammable solid</td>
<td>NA</td>
<td>H-3</td>
<td>125&lt;sup&gt;d, e&lt;/sup&gt;</td>
<td>NA</td>
<td>125&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inert gas</td>
<td>Cased liquid</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>UD</td>
<td>H-1</td>
<td>1&lt;sup&gt;f&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>H-2</td>
<td>5&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(5)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>H-3</td>
<td>50&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(50)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>H-3</td>
<td>125&lt;sup&gt;k, e&lt;/sup&gt;</td>
<td>(125)&lt;sup&gt;k, e&lt;/sup&gt;</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>Organic peroxide</td>
<td></td>
<td>H-1</td>
<td>1&lt;sup&gt;h&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>H-2 or H-3</td>
<td>10&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(10)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>H-3</td>
<td>250&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>(250)&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>250&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(100)&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>4,000&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>(4,000)&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>4,000&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oxidizer</td>
<td>4</td>
<td>H-1</td>
<td>1&lt;sup&gt;g&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>H-2 or H-3</td>
<td>10&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(10)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>H-3</td>
<td>250&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>(250)&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>WA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>H-1 or H-2</td>
<td>1&lt;sup&gt;g&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>H-3</td>
<td>50&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(50)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oxidizing gas</td>
<td>Cased liquid</td>
<td>H-3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(150)&lt;sup&gt;a, e&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
<td>(500)&lt;sup&gt;a, e&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.500&lt;sup&gt;c&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
<td>1.500&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(150)&lt;sup&gt;a, e&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
<td>(150)&lt;sup&gt;a, e&lt;/sup&gt;</td>
</tr>
<tr>
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<td></td>
<td>(4,000)&lt;sup&gt;e, f&lt;/sup&gt;</td>
<td>NA</td>
<td>NA</td>
<td>(4,000)&lt;sup&gt;e, f&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pyrophoric</td>
<td>NA</td>
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<td>4&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(4)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>50&lt;sup&gt;e&lt;/sup&gt;</td>
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<tr>
<td></td>
<td></td>
<td>(250)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(250)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(250)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(250)&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unstable (reactive)</td>
<td>4</td>
<td>H-1 or H-2</td>
<td>1&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(1)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>H-3</td>
<td>50&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(50)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>Water reactive</td>
<td>3</td>
<td>H-2</td>
<td>5&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(5)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>H-3</td>
<td>50&lt;sup&gt;e&lt;/sup&gt;</td>
<td>(50)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.25&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
For SI: 1 cubic foot = 0.028 m³, 1 pound = 0.454 kg, 1 gallon = 3.785 L.

NL = Not Limited; NA = Not Applicable; UD = Unclassified Detonable.

a. For use of control areas, see Clause 4.14.2.
b. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.
c. The quantities of alcoholic beverages in retail and wholesale sales occupancies shall not be limited provided the liquids are packaged in individual containers not exceeding 1.3 gallons. In retail and wholesale sales occupancies, the quantities of medicines, foodstuffs or consumer products, and cosmetics containing not more than 50 percent by volume of water-miscible liquids with the remainder of the solutions not being flammable, shall not be limited, provided that such materials are packaged in individual containers not exceeding 1.3 gallons.
d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1. Where Note e also applies, the increase for both notes shall be applied accumulatively.
e. Maximum allowable quantities shall be increased 100 percent when stored in approved storage cabinets, day boxes, gas cabinets, gas rooms or exhausted enclosures or in listed safety cans in accordance with Clause 5003.9.10 of the Ghana Fire Code. Where Note d also applies, the increase for both notes shall be applied accumulatively.
f. Quantities shall not be limited in a building equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

g. Allowed only in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.
h. Containing not more than the maximum allowable quantity per control area of Class IA, IB or IC flammable liquids.
i. The maximum allowable quantity shall not apply to fuel oil storage complying with the Ghana Fire Code.
j. Quantities in parentheses indicate quantity units in parentheses at the head of each column.
k. A maximum quantity of 220 pounds of solid or 22 gallons of liquid Class 3 oxidizers is allowed when such materials are necessary for maintenance purposes, operation or sanitation of equipment when the storage containers and the manner of storage are approved.
l. Net weight of the pyrotechnic composition of the fireworks. Where the net weight of the pyrotechnic composition of the fireworks is not known, 25 percent of the gross weight of the fireworks, including packaging, shall be used.
m. For gallons of liquids, divide the amount in pounds by 10 in accordance with the Ghana Fire Code.
n. For storage and display quantities in Group M and storage quantities in Group S occupancies complying with this Code.
o. Densely packed baled cotton that complies with the packing requirements of ISO 8115 shall not be included in this material class.
p. The following shall not be included in determining the maximum allowable quantities:
   1. Liquid or gaseous fuel in fuel tanks on vehicles.
   2. Liquid or gaseous fuel in fuel tanks on motorized equipment operated in accordance with the Ghana Fire Code.
   3. Gaseous fuels in piping systems and fixed appliances regulated by this Code.
   4. Liquid fuels in piping systems and fixed appliances regulated by this Code.
   5. Alcohol-based hand rubs classified as Class I or II liquids in dispensers that are installed in accordance with the Ghana Fire Code. The location of the alcohol-based hand rub (ABHR) dispensers shall be provided in the construction documents.
q. Where manufactured, generated or used in such a manner that the concentration and conditions create a fire or explosion hazard based on information prepared in accordance with this Code.
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STORAGE $^b$</th>
<th>USE-CLOSED SYSTEMS $^b$</th>
<th>USE-OPEN SYSTEMS $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solid d, e</td>
<td>Liquid gallons (pounds) d, e</td>
<td>Solid d, e</td>
</tr>
<tr>
<td></td>
<td>Gas cubic feet at NTP d</td>
<td>Liquid gallons (pounds) d</td>
<td>Solid d, e</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Liquid gallons (pounds) d</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Gas cubic feet at NTP d, e</td>
</tr>
<tr>
<td>Corrosives</td>
<td>5,000</td>
<td>500</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>Highly Toxic</td>
<td>10</td>
<td>(10)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(10)</td>
</tr>
<tr>
<td>Toxic</td>
<td>500</td>
<td>(500)</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(500)</td>
</tr>
</tbody>
</table>

For SI: 1 cubic foot = 0.028 m$^3$, 1 pound = 0.454 kg, 1 gallon = 3.785 L.

- a. For use of control areas.
- b. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.
- c. In retail and wholesale sales occupancies, the quantities of medicines, foodstuffs or consumer products, and cosmetics containing not more than 50 percent by volume of water-miscible liquids and with the remainder of the solutions not being flammable, shall not be limited, provided that such materials are packaged in individual containers not exceeding 1.3 gallons.
- d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an approved automatic sprinkler system in accordance with this Code. Where Note e also applies, the increase for both notes shall be applied accumulatively.
- e. Maximum allowable quantities shall be increased 100 percent where stored in approved storage cabinets, gas cabinets or exhausted enclosures as specified in the Ghana Fire Code. Where Note d also applies, the increase for both notes shall be applied accumulatively.
- f. For storage and display quantities in Group M and storage quantities in Group S occupancies complying with this Code.
- g. Allowed only where stored in approved exhausted gas cabinets or exhausted enclosures as specified in the Ghana Fire Code.
- h. Quantities in parentheses indicate quantity units in parentheses at the head of each column.
- i. For gallons of liquids, divide the amount in pounds by 10.
3.7.1.1 Uses other than Group H.
An occupancy that stores, uses or handles hazardous materials as described in one or more of the following items shall not be classified as Group H, but shall be classified as the occupancy that it most nearly resembles.

1. Buildings and structures occupied for the application of flammable finishes, provided that such buildings or areas conform to the requirements of the Ghana Fire Code.

2. Wholesale and retail sales and storage of flammable and combustible liquids in mercantile occupancies conforming to the Ghana Fire Code.

3. Closed piping system containing flammable or combustible liquids or gases utilized for the operation of machinery or equipment.

4. Cleaning establishments that utilize combustible liquid solvents having a flash point of 140°F (60°C) or higher in closed systems employing equipment listed by an approved testing agency, provided that this occupancy is separated from all other areas of the building by 1-hour fire barriers constructed in accordance with Clause 8.7 or 1-hour horizontal assemblies constructed in accordance with Clause 8.11, or both.

5. Cleaning establishments that utilize a liquid solvent having a flash point at or above 93°C (200°F).


7. Refrigeration systems.

8. The storage or utilization of materials for agricultural purposes on the premises.

9. Stationary storage battery systems installed in accordance with the Ghana Fire Code.

10. Corrosive personal or household products in their original packaging used in retail display.

11. Commonly used corrosive building materials.

12. Buildings and structures occupied for aerosol product storage shall be classified as Group S-1, provided that such buildings conform to the requirements of the Ghana Fire Code.

13. Display and storage of nonflammable solid and nonflammable or noncombustible liquid hazardous materials in quantities not exceeding the maximum allowable quantity per control area in Group M or S occupancies complying with this Code.

14. The storage of black powder, smokeless propellant and small arms primers in Groups M and R-3 and special industrial explosive devices in Groups B, F, M and S, provided such storage conforms to the quantity limits and requirements prescribed in the Ghana Fire Code.

15. Stationary fuel cell power systems installed in accordance with the Ghana Fire Code.

16. Capacitor energy storage systems in accordance with the Ghana Fire Code.

17. Group B higher education laboratory occupancies complying with this Code and the Ghana Fire Code.

3.7.2 Hazardous materials.
Hazardous materials in any quantity shall conform to the requirements of this Code, including Clause 4.14, and the Ghana Fire Code.

3.7.3 High-hazard Group H-1.
Buildings and structures containing materials that pose a detonation hazard shall be classified as Group H-1. Such materials shall include, but not be limited to, the following:

Detonable pyrophoric materials
Explosives:
Division 1.1
Division 1.2
Division 1.3
Division 1.4
Division 1.5
Division 1.6

Organic peroxides, unclassified detonable
Oxidizers, Class 4
Unstable (reactive) materials, Class 3 detonable and Class 4

3.7.3.1 Occupancies containing explosives not classified as H-1.
The following occupancies containing explosive materials shall be classified as follows:

1. Division 1.3 explosive materials that are used and maintained in a form where either confinement or configuration will not elevate the hazard from a mass fire to mass explosion hazard shall be allowed in H-2 occupancies.

2. Articles, including articles packaged for shipment, that are not regulated as a Division 1.4 explosive under Bureau of Alcohol, Tobacco, Firearms and Explosives regulations, or unpackaged articles used in process operations that do not propagate a detonation or deflagration between articles shall be allowed in H-3 occupancies.

3.7.4 High-hazard Group H-2.
Buildings and structures containing materials that pose a deflagration hazard or a hazard from accelerated burning shall be classified as Group H-2. Such materials shall include, but not be limited to, the following:

Class I, II or IIIA flammable or combustible liquids that are used or stored in normally open containers or systems, or in closed containers or systems pressurized at more than 15 pounds per square inch gauge (103.4 kPa).

Combustible dusts where manufactured, generated or used in such a manner that the concentration and conditions create a fire or explosion hazard based on information prepared in accordance with this Code.
Cryogenic fluids, flammable.
Flammable gases.
Organic peroxides, Class I.
Oxidizers, Class 3, that are used or stored in normally open containers or systems, or in closed containers or systems pressurized at more than 15 pounds per square inch gauge (103 kPa).

Pyrophoric liquids, solids and gases, non-detonable.
Unstable (reactive) materials, Class 3, non-detonable.
Water-reactive materials, Class 3.

3.7.5 High-hazard Group H-3.
Buildings and structures containing materials that readily support combustion or that pose a physical hazard shall be classified as Group H-3. Such materials shall include, but not be limited to, the following:

Class I, II or IIIA flammable or combustible liquids that are used or stored in normally closed containers or systems pressurized at 15 pounds per square inch gauge (103.4 kPa) or less.

Combustible fibers, other than densely packed baled cotton, where manufactured, generated or used in such a manner that the concentration and conditions create a fire or explosion hazard based on information prepared in accordance with Clause 4.14.1.3.
Consumer fireworks, 1.4G (Class C, Common)
Cryogenic fluids, oxidizing
Flammable solids
Organic peroxides, Class II and III
Oxidizers, Class 2
Oxidizers, Class 3, that are used or stored in normally closed containers or systems pressurized at 15 pounds per square inch gauge (103 kPa) or less
Oxidizing gases
Unstable (reactive) materials, Class 2
Water-reactive materials, Class 2

3.7.6 High-hazard Group H-4.
Buildings and structures containing materials that are health hazards shall be classified as Group H-4. Such materials shall include, but not be limited to, the following:

Corrosives
Highly toxic materials
Toxic materials

3.7.7 High-hazard Group H-5.
Semiconductor fabrication facilities and comparable research and development areas in which hazardous production materials (HPM) are used and the aggregate quantity of materials is in excess of those listed in Tables 3.7.1(1) and 3.7.1(2) shall be classified as Group H-5. Such facilities and areas shall be designed and constructed in accordance with Clause 4.15.11.

3.7.8 Multiple hazards.
Buildings and structures containing a material or materials representing hazards that are
3.8 INSTITUTIONAL GROUP I

3.8.1 Institutional Group I.

Institutional Group I occupancy includes, among others, the use of a building or structure, or a portion thereof, in which care or supervision is provided to persons who are or are not capable of self-preservation without physical assistance or in which persons are detained for penal or correctional purposes or in which the liberty of the occupants is restricted. Institutional occupancies shall be classified as Group I-1, I-2, I-3 or I-4.

3.8.2 Institutional Group I-1.

Institutional Group I-1 occupancy shall include buildings, structures or portions thereof for more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised environment and receive custodial care. Buildings of Group I-1 shall be classified as one of the occupancy conditions specified in Clause 3.8.2.1 or 3.8.2.2. This group shall include, but not be limited to, the following:

- Alcohol and drug centers
- Assisted living facilities
- Congregate care facilities
- Group homes
- Halfway houses
- Residential board and care facilities
- Social rehabilitation facilities

3.8.2.1 Condition 1.

This occupancy condition shall include buildings in which all persons receiving custodial care who, without any assistance, are capable of responding to an emergency situation to complete building evacuation.

3.8.2.2 Condition 2.

This occupancy condition shall include buildings in which there are any persons receiving custodial care who require limited verbal or physical assistance while responding to an emergency situation to complete building evacuation.

3.8.2.3 Six to 16 persons receiving custodial care.

A facility housing not fewer than six and not more than 16 persons receiving custodial care shall be classified as Group R-4.

3.8.2.4 Five or fewer persons receiving custodial care.

A facility with five or fewer persons receiving custodial care shall be classified as Group R-3 or shall comply with the International Residential Code provided an automatic sprinkler system is installed in accordance with Clause 10.3.3.1.3.

3.8.3 Institutional Group I-2.

Institutional Group I-2 occupancy shall include buildings and structures used for medical care on a 24-hour basis for more than five persons who are incapable of self-preservation. This group shall include, but not be limited to, the following:

- Foster care facilities
- Detoxification facilities
- Hospitals
- Nursing homes
- Psychiatric hospitals

3.8.3.1 Occupancy conditions.

Buildings of Group I-2 shall be classified as one of the occupancy conditions specified in Clause 3.8.3.1.1 or 3.8.3.1.2.

3.8.3.1.1 Condition 1.

This occupancy condition shall include facilities that provide nursing and medical care but do not provide emergency care, surgery, obstetrics or in-patient stabilization units for psychiatric or detoxification, including but not limited to nursing homes and foster care facilities.

3.8.3.1.2 Condition 2.

This occupancy condition shall include facilities that provide nursing and medical care and could provide emergency care, surgery, obstetrics or in-patient stabilization units for psychiatric or detoxification, including but not limited to hospitals.

3.8.3.2 Five or fewer persons receiving medical care.

A facility with five or fewer persons receiving medical care shall be classified as Group R-3 or shall comply with the International Residential Code provided an automatic sprinkler system is installed in accordance with Clause 10.3.3.1.3.
3.8.4 Institutional Group I-3.

Institutional Group I-3 occupancy shall include buildings and structures that are inhabited by more than five persons who are under restraint or security. A Group I-3 facility is occupied by persons who are generally incapable of self-preservation due to security measures not under the occupants’ control. This group shall include, but not be limited to, the following:

- Correctional centers
- Detention centers
- Jails
- Prerlease centers
- Prisons
- Reformatories

Buildings of Group I-3 shall be classified as one of the occupancy conditions specified in Clauses 3.8.4.1 through 3.8.4.5 (see Clause 4.8.1).

3.8.4.1 Condition 1.

This occupancy condition shall include buildings in which free movement is allowed from sleeping areas, and other spaces where access or occupancy is permitted, to the exterior via means of escape without restraint. A Condition 1 facility is permitted to be constructed as Group R.

3.8.4.2 Condition 2.

This occupancy condition shall include buildings in which free movement is allowed from sleeping areas and any other occupied smoke compartment to one or more other smoke compartments. Escape to the exterior is impeded by locked exits.

3.8.4.3 Condition 3.

This occupancy condition shall include buildings in which free movement is allowed within individual smoke compartments such as within a residential unit comprised of individual sleeping units and group activity spaces, where escape is impeded by remote-controlled release of means of escape from such a smoke compartment to another smoke compartment.

3.8.4.4 Condition 4.

This occupancy condition shall include buildings in which free movement is restricted from an occupied space. Remote-controlled release is provided to permit movement from sleeping units, activity spaces and other occupied areas within the smoke compartment to other smoke compartments.

3.8.4.5 Condition 5.

This occupancy condition shall include buildings in which free movement is restricted from an occupied space. Staff-controlled manual release is provided to permit movement from sleeping units, activity spaces and other occupied areas within the smoke compartment to other smoke compartments.

3.8.5 Institutional Group I-4, day care facilities.

Institutional Group I-4 occupancy shall include buildings and structures occupied by more than five persons of any age who receive custodial care for fewer than 24 hours per day by persons other than parents or guardians, relatives by blood, marriage or adoption, and in a place other than the home of the person cared for. This group shall include, but not be limited to, the following:

- Adult day care
- Child day care

3.8.5.1 Classification as Group E.

A child day care facility that provides care for more than five but not more than 100 children 1, 2 years or less of age, where the rooms in which the children are cared for are located on a level of exit discharge serving such rooms and each of these child care rooms has an exit door directly to the exterior, shall be classified as Group E.

3.8.5.2 Within a place of religious worship.

Rooms and spaces within places of religious worship providing such care during religious functions shall be classified as part of the primary occupancy.

3.8.5.3 Five or fewer persons receiving care.

A facility having five or fewer persons receiving custodial care shall be classified as part of the primary occupancy.

3.8.5.4 Five or fewer persons receiving care in a dwelling unit.

A facility such as the above within a dwelling unit and having five or fewer persons receiving custodial care shall be classified as a Group R-3 occupancy or shall comply with this Code.
3.9 MERCANTILE GROUP M

3.9.1 Mercantile Group M.
Mercantile Group M occupancy includes, among others, the use of a building or structure or a portion thereof for the display and sale of merchandise, and involves stocks of goods, wares or merchandise incidental to such purposes and accessible to the public. Mercantile occupancies shall include, but not be limited to, the following:

- Department stores
- Drug stores
- Markets
- Greenhouses for display and sale of plants that provide public access.
- Motor fuel-dispensing facilities
- Retail or wholesale stores
- Sales rooms

3.9.2 Quantity of hazardous materials.
The aggregate quantity of nonflammable solid and nonflammable or noncombustible liquid hazardous materials stored or displayed in a single control area of a Group M occupancy shall not exceed the quantities in Table 4.14.2.5(1).

3.10 RESIDENTIAL GROUP R

3.10.1 Residential Group R.
Residential Group R includes, among others, the use of a building or structure, or a portion thereof, for sleeping purposes when not classified as an Institutional Group I.

3.10.2 Residential Group R-1.
Residential Group R-1 occupancies containing sleeping units where the occupants are primarily transient in nature, including:

- Boarding houses (transient) with more than 10 occupants
- Congregate living facilities (transient) with more than 10 occupants
- Hotels (transient)
- Motels (transient)

3.10.3 Residential Group R-2.
Residential Group R-2 occupancies containing sleeping units or more than two dwelling units where the occupants are primarily permanent in nature, including:

- Apartment houses
- Congregate living facilities (nontransient) with more than 16 occupants
- Boarding houses (nontransient)
- Convents
- Dormitories
- Fraternities and sororities
- Monasteries
- Hotels (nontransient)
- Live/work units
- Motels (nontransient)
- Vacation timeshare properties

3.10.4 Residential Group R-3.
Residential Group R-3 occupancies where the occupants are primarily permanent in nature and not classified as Group R-1, R-2, R-4 or I, including:

- Buildings that do not contain more than two dwelling units
- Care facilities that provide accommodations for five or fewer persons receiving care
- Congregate living facilities (nontransient) with 16 or fewer occupants
- Boarding houses (nontransient)
- Convents
- Dormitories
- Fraternities and sororities
- Monasteries
- Congregate living facilities (transient) with 10 or fewer occupants
- Boarding houses (transient)
- Lodging houses (transient) with five or fewer guest rooms and 10 or fewer occupants

3.10.4.1 Care facilities within a dwelling.
Care facilities for five or fewer persons receiving care that are within a single-family dwelling are permitted to comply with this Code provided an automatic sprinkler system is installed in accordance with Clause 10.3.3.1.3.

3.10.4.2 Lodging houses.
Owner-occupied lodging houses with five or fewer guest rooms and 10 or fewer total occupants shall be permitted to be constructed in accordance with this Code.

3.10.5 Residential Group R-4.
Residential Group R-4 occupancy shall include buildings, structures or portions thereof for more than five but not more than 16 persons, excluding staff, who reside on a 24-hour basis in a supervised residential environment and receive custodial care. Buildings of Group R-4 shall be classified as one of the occupancy conditions specified in Clause 3.10.5.1 or
3.10.5.2. This group shall include, but not be limited to, the following:

- Alcohol and drug centers
- Assisted living facilities
- Congregate care facilities
- Group homes
- Halfway houses
- Residential board and care facilities
- Social rehabilitation facilities

Group R-4 occupancies shall meet the requirements for construction as defined for Group R-3, except as otherwise provided for in this Code.

3.10.5.1 Condition 1.
This occupancy condition shall include buildings in which all persons receiving custodial care, without any assistance, are capable of responding to an emergency situation to complete building evacuation.

3.10.5.2 Condition 2.
This occupancy condition shall include buildings in which there are any persons receiving custodial care who require limited verbal or physical assistance while responding to an emergency situation to complete building evacuation.

3.11 STORAGE GROUP S

3.11.1 Storage Group S.
Storage Group S occupancy includes, among others, the use of a building or structure, or a portion thereof, for storage that is not classified as a hazardous occupancy.

3.11.1.1 Accessory storage spaces.
A room or space used for storage purposes that is accessory to another occupancy shall be classified as part of that occupancy.

3.11.2 Moderate-hazard storage, Group S-1.
Storage Group S-1 occupancies are buildings occupied for storage uses that are not classified as Group S-2, including, but not limited to, storage of the following:

- Aerosol products, Levels 2 and 3
- Aircraft hangar (storage and repair)
- Bags: cloth, burlap and paper
- Bamboos and rattan
- Baskets
- Belting: canvas and leather
- Books and paper in rolls or packs
- Boots and shoes
- Buttons, including cloth covered, pearl or bone
- Cardboard and cardboard boxes
- Clothing, woolen wearing apparel
- Cordage
- Dry boat storage (indoor)
- Furniture
- Furs
- Glues, mucilage, pastes and size
- Grains
- Horns and combs, other than celluloid
- Leather
- Linoleum
- Timber
- Motor vehicle repair garages complying with the maximum allowable quantities of hazardous materials listed in Table 3.7.1(1) (see Clause 4.6.8)
- Photo engravings
- Resilient flooring
- Self-service storage facility (mini-storage)
- Silks
- Soaps
- Sugar
- Tires, bulk storage of
- Tobacco, cigars, cigarettes and snuff
- Upholstery and mattresses
- Wax candles

3.11.3 Low-hazard storage, Group S-2.
Storage Group S-2 occupancies include, among others, buildings used for the storage of noncombustible materials such as products on wood pallets or in paper cartons with or without single thickness divisions; or in paper wrappings. Such products are permitted to have a negligible amount of plastic trim, such as knobs, handles or film wrapping. Group S-2 storage uses shall include, but not be limited to, storage of the following:

- Beverages up to and including 16-percent alcohol in metal, glass or ceramic containers
- Cement in bags
- Chalk and crayons
- Dairy products in nonwaxed coated paper containers
- Dry cell batteries
- Electrical coils
- Electrical motors
- Empty cans
- Food products
- Foods in noncombustible containers
- Fresh fruits and vegetables in nonplastic trays or containers
- Frozen foods
- Glass
Glass bottles, empty or filled with noncombustible liquids
Gypsum board
Inert pigments
Ivory
Meats
Metal cabinets
Metal desks with plastic tops and trim
Metal parts
Metals
Mirrors
Oil-filled and other types of distribution transformers
Parking garages, open or enclosed
Porcelain and pottery
Stoves
Talc and soapstones
Washers and dryers

3.12 UTILITY AND MISCELLANEOUS GROUP U

3.12.1 General.
Buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to the requirements of this Code commensurate with the fire and life hazard incidental to their occupancy. Group U shall include, but not be limited to, the following:

Agricultural buildings
Aircraft hangars, accessory to a one- or two-family residence (see Clause 4.12.4)
Barns
Carports
Communication equipment structures with a gross floor area of less than 139 m² (1,500 square feet)
Fences more than 1829 mm (6 feet) in height
Grain silos, accessory to a residential occupancy
Livestock shelters
Private garages
Retaining walls
Sheds
Stables
Tanks
Towers

3.12.1.1 Greenhouses.
Greenhouses not classified as another occupancy shall be classified as Use Group U.
PART 4: SPECIAL DETAILED REQUIREMENTS BASED ON OCCUPANCY AND USE

User note:

About this part: Part 4 provides detailed criteria for special uses and occupancies. The unique characteristics of a live/work unit as opposed to a 30-storey high-rise building call for specific standards for each. Twenty-seven clauses address covered and open mall buildings, atriums, hospitals, stages, buildings where hazardous materials are used and stored, jails and prisons, ambulatory care facilities and storm shelters, among other special occupancy issues.

4.1 SCOPE

4.1.1 Detailed occupancy and use requirements.
In addition to the occupancy and construction requirements in this Code, the provisions of this part apply to the occupancies and use described herein.

4.2 COVERED MALL AND OPEN MALL BUILDINGS

4.2.1 Applicability.
The provisions of this clause shall apply to buildings or structures defined herein as covered or open mall buildings not exceeding three floor levels at any point nor more than three stories above grade plane. Except as specifically required by this clause, covered and open mall buildings shall meet applicable provisions of this Code.

Exceptions:
1. Foyers and lobbies of Groups B, R-1 and R-2 are not required to comply with this clause.
2. Buildings need not comply with the provisions of this clause where they totally comply with other applicable provisions of this Code.

4.2.1.1 Open mall building perimeter line.
For the purpose of this Code, a perimeter line shall be established. The perimeter line shall encircle all buildings and structures that comprise the open mall building and shall encompass any open-air interior walkways, open-air courtyards or similar open-air spaces. The perimeter line shall define the extent of the open mall building. Anchor buildings and parking structures shall be outside of the perimeter line and are not considered as part of the open mall building.

4.2.2 Open space.
A covered mall building and attached anchor buildings and parking garages shall be surrounded on all sides by a permanent open space or not less than 18 288 mm (60 feet). An open mall building and anchor buildings and parking garages adjoining the perimeter line shall be surrounded on all sides by a permanent open space of not less than 18 288 mm (60 feet).

Exception: The permanent open space of 18 288 mm (60 feet) shall be permitted to be reduced to not less than 12 192 mm (40 feet), provided that the following requirements are met:
1. The reduced open space shall not be allowed for more than 75 percent of the perimeter of the covered or open mall building and anchor buildings.
2. The exterior wall facing the reduced open space shall have a fire-resistance rating of not less than 3 hours.
3. Openings in the exterior wall facing the reduced open space shall have opening protectives with a fire protection rating of not less than 3 hours.
4. Group E, H, I or R occupancies are not located within the covered or open mall building or anchor buildings.

4.2.3 Lease plan.
Each owner of a covered mall building or of an open mall building shall provide both the building and fire departments with a lease plan showing the location of each occupancy and its exits after the certificate of occupancy has been issued. Modifications or changes in occupancy or use from that shown on the lease plan shall not be made without prior approval of the building official.

4.2.4 Construction.
The construction of covered and open mall buildings, anchor buildings and parking
garages associated with a mall building shall comply with Clauses 4.2.4.1 through 4.2.4.3.

4.2.4.1 Area and types of construction.
The building area and type of construction of covered mall or open mall buildings, anchor buildings and parking garages shall comply with this clause.

4.2.4.1.1 Covered and open mall buildings.
The building area of any covered mall or open mall building shall not be limited provided that the covered mall or open mall building does not exceed three floor levels at any point nor three stories above grade plane, and is of Type I, II or III construction.

4.2.4.1.2 Anchor buildings.
The building area and building height of any anchor building shall be based on the type of construction as required by this Code.

Exception: The building area of any anchor building shall not be limited provided that the anchor building is not more than three stories above grade plane, and is of Type I, II or III construction.

4.2.4.1.3 Parking garage.
The building area and building height of any parking garage shall be based on the type of construction as required by Clauses 4.6.5 and 4.6.6, respectively.

4.2.4.2 Fire-resistance-rated separation.
Fire-resistance-rated separation is not required between tenant spaces and the mall. Fire-resistance-rated separation is not required between a food court and adjacent tenant spaces or the mall.

4.2.4.2.1 Tenant separations.
Each tenant space shall be separated from other tenant spaces by a fire partition complying with this Code.

4.2.4.2.2 Anchor building separation.
An anchor building shall be separated from the covered or open mall building by fire walls complying with this Code.

Exceptions:

1. Anchor buildings of not more than three stories above grade plane that have an occupancy classification the same as that permitted for tenants of the mall building shall be separated by 2-hour fire-resistance-rated fire barriers complying with this Code.

2. The exterior walls of anchor buildings separated from an open mall building by an open mall shall comply with Table 7.2

4.2.4.2.3 Parking garages.
An attached garage for the storage of passenger vehicles having a capacity of not more than nine persons and open parking garages shall be considered as a separate building where it is separated from the covered or open mall building or anchor building by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

Parking garages, which are separated from covered mall buildings, open mall buildings or anchor buildings, shall comply with the provisions of Table 7.2.

Pedestrian walkways and tunnels that connect garages to mall buildings or anchor buildings shall be constructed in accordance with Clause 32.4.

4.2.4.3 Open mall construction.

Floor assemblies in, and roof assemblies over, the open mall of an open mall building shall be open to the atmosphere for not less than 9096 mm (30 feet), measured perpendicular from the face of the tenant spaces on the lowest level, from edge of balcony to edge of balcony on upper floors and from edge of roof line to edge of roof line. The openings within, or the unroofed area of, an open mall shall extend from the lowest/grade level of the open mall through the entire roof assembly. Balconies on upper levels of the mall shall not project into the required width of the opening.
4.2.4.3.1 Pedestrian walkways.
Pedestrian walkways connecting balconies in an open mall shall be located not less than 9096 mm (20 feet) from any other pedestrian walkway.

4.2.5 Automatic sprinkler system.
Covered and open mall buildings and buildings connected shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, which shall comply with all of the following:

1. The automatic sprinkler system shall be complete and operative throughout occupied space in the mall building prior to occupancy of any of the tenant spaces. Unoccupied tenant spaces shall be similarly protected unless provided with approved alternative protection.

2. Sprinkler protection for the mall of a covered mall building shall be independent from that provided for tenant spaces or anchor buildings.

3. Sprinkler protection for the tenant spaces of an open mall building shall be independent from that provided for anchor buildings.

4. Sprinkler protection shall be provided beneath exterior circulation balconies located adjacent to an open mall.

5. Where tenant spaces are supplied by the same system, they shall be independently controlled.

Exception: An automatic sprinkler system shall not be required in spaces or areas of open parking garages separated from the covered or open mall building in accordance with Clause 4.2.4.2.3 and constructed in accordance with Clause 4.6.5.

4.2.6 Interior finishes and features.
Interior finishes within the mall and installations within the mall shall comply with Clauses 4.2.6.1 through 4.2.6.4.

4.2.6.1 Interior finish.
Interior wall and ceiling finishes within the mall of a covered mall building and within the exits of covered or open mall buildings shall have a minimum flame spread index and smoke-developed index of Class B in accordance with Part 9 Interior floor finishes shall meet the requirements of Clause 9.4.

4.2.6.2 Kiosks.
Kiosks and similar structures (temporary or permanent) located within the mall of a covered mall building or within the perimeter line of an open mall building shall meet the following requirements:

1. Combustible kiosks or other structures shall not be located within a covered or open mall unless constructed of any of the following materials:

   1.1. Fire-retardant-treated wood complying with this Code.

   1.2. Foam plastics having a maximum heat release rate not greater than 100 kW (105 Btu/h) when tested using the 20 kW ignition source shall meet the requirements of this Code.

   1.3. Aluminum composite material (ACM) meeting the requirements of Class A interior finish in accordance with Part 9 when tested as an assembly in the maximum thickness intended.

2. Kiosks or similar structures located within the mall shall be provided with approved automatic sprinkler system and detection devices.

3. The horizontal separation between kiosks or groupings thereof and other structures within the mall shall be not less than 6096 mm (20 feet).

4. Each kiosk or similar structure or groupings thereof shall have an area not greater than 28 m² (300 square feet).

4.2.6.3 Children’s play structures.
Children’s play structures located within the mall of a covered mall building or within the perimeter line of an open mall building shall comply with Clause 4.24. The horizontal
separation between children’s play structures, kiosks and similar structures within the mall shall be not less than 6096 mm (20 feet).

4.2.6.4 Plastic signs.
Plastic signs affixed to the storefront of any tenant space facing a mall or open mall shall be limited as specified in Clauses 4.2.6.4.1 through 4.2.6.4.5.

4.2.6.4.1 Area.
Plastic signs shall be not more than 20 percent of the wall area facing the mall.

4.2.6.4.2 Height and width.
Plastic signs shall be not greater than 914 mm (36 inches) in height, except that where the sign is vertical, the height shall be not greater than 2438 mm (96 inches) and the width shall be not greater than 914 mm (36 inches).

4.2.6.4.3 Location.
Plastic signs shall be located not less than 457 mm (18 inches) from adjacent tenants.

4.2.6.4.4 Plastics other than foam plastics.
Plastics other than foam plastics used in signs shall be light-transmitting plastics complying with this Code or shall have a self-ignition temperature of 343°C (650°F) or greater when tested in accordance with ASTM D1929, and a flame spread index not greater than 75 and smoke-developed index not greater than 450 when tested in the manner intended for use in accordance with ASTM E84 or meet the acceptance criteria of this Code when tested in accordance with ASTM-E84

4.2.6.4.4.1 Encasement.
Edges and backs of plastic signs in the mall shall be fully encased in metal.

4.2.6.4.5 Foam plastics.
Foam plastics used in signs shall have flame-retardant characteristics such that the sign has a maximum heat-release rate of 150 kilowatts when tested or when tested in accordance with ASTM-E84 using the 20 kW ignition source, and the foam plastics shall have the physical characteristics specified in this Code. Foam plastics used in signs installed in accordance with Clause 4.2.6.4 shall not be required to comply with the flame spread and smoke-developed indices specified in this Code.

4.2.6.4.5.1 Density.
The density of foam plastics used in signs shall be not less than 20 pounds per cubic foot (pcf) (320 kg/ m³).

4.2.6.4.5.2 Thickness.
The thickness of foam plastic signs shall not be greater than 12.7 mm (1/2 inch).

4.2.7 Emergency systems.
Covered and open mall buildings, anchor buildings and associated parking garages shall be provided with emergency systems complying with Clauses 4.2.7.1 through 4.2.7.5.

4.2.7.1 Fire hydrant system.
Covered and open mall buildings shall be equipped throughout with a Fire hydrant system as required by this Code.

4.2.7.2 Smoke control.
Where a covered mall building contains an atrium, a smoke control system shall be provided in accordance with Clause 4.4.5.

Exception: A smoke control system is not required in covered mall buildings where an atrium connects only two stories.

4.2.7.3 Emergency power.
Covered mall buildings greater than 4645 m² (50,000 square feet) in area and open mall buildings greater than 4645 m² (50,000 square feet) within the established perimeter line shall be provided with emergency power that is capable of operating the emergency voice/alarm communication system in accordance with this Code.

4.2.7.4 Emergency voice/alarm communication system.
Where the total floor area is greater than 4645 m² (50,000 square feet) within either a covered mall building or within the perimeter line of an open mall building, an emergency voice/alarm communication system shall be provided.

The fire department shall have access to any emergency voice/alarm communication systems serving a mall, required or otherwise. The systems shall be provided in accordance with this Code.
4.2.7.5 Fire department access to equipment.

Rooms or areas containing controls for air-conditioning systems, automatic fire-extinguishing systems, automatic sprinkler systems or other detection, suppression or control elements shall be identified for use by the fire department.

4.2.8 Means of escape.

Covered mall buildings, open mall buildings and each tenant space within a mall building shall be provided with means of escape as required by this clause and this Code. Where there is a conflict between the requirements of this Code and the requirements of Clauses 4.2.8.1 through 4.2.8.8, the requirements of Clauses 4.2.8.1 through 4.2.8.8 shall apply.

4.2.8.1 Mall width.
For the purpose of providing required escape, malls are permitted to be considered as corridors but need not comply with the requirements of this Code where the width of the mall is as specified in this clause.

4.2.8.1.1 Minimum width.
The aggregate clear escape width of the mall in either a covered or open mall building shall be not less than 6096 mm (20 feet). The mall width shall be sufficient to accommodate the occupant load served. Any portion of the minimum required aggregate escape width shall be not less than 3048 mm (10 feet) measured to a height of 2438 mm (8 feet) between any projection of a tenant space bordering the mall and the nearest kiosk, vending machine, bench, display opening, food court or other obstruction to means of escape travel.

4.2.8.2 Determination of occupant load.
The occupant load permitted in any individual tenant space in a covered or open mall building shall be determined as required by this Code. Means of escape requirements for individual tenant spaces shall be based on the occupant load thus determined.

4.2.8.2.1 Occupant formula.
In determining required means of escape of the mall, the number of occupants for whom means of escape are to be provided shall be based on gross leasable area of the covered or open mall building (excluding anchor buildings) and the occupant load factor as determined by Equation 4-1.

\[
OLF = (0.00007)(GLA) + 25
\]

Where:

- OLF = The occupant load factor (square feet per person)
- GLA = The gross leasable area (square feet).

Exception: Tenant spaces attached to a covered or open mall building but with a means of escape system that is totally independent of the open mall of an open mall building or of a covered mall building shall not be considered as gross leasable area for determining the required means of escape for the mall building.

4.2.8.2.2 OLF range.
The occupant load factor (OLF) is not required to be less than 30 and shall not exceed 50.

4.2.8.2.3 Anchor buildings.
The occupant load of anchor buildings opening into the mall shall not be included in computing the total number of occupants for the mall.

4.2.8.2.4 Food courts.
The occupant load of a food court shall be determined in accordance with this Code. For the purposes of determining the means of escape requirements for the mall, the food court occupant load shall be added to the occupant load of the covered or open mall building as calculated in Clause 4.2.8.2.1.

4.2.8.3 Number of means of escape.
Wherever the distance of travel to the mall from any location within a tenant space used by persons other than employees is greater than 22860 mm (75 feet) or the tenant space has an occupant load of 50 or more, not fewer than two means of escape shall be provided.

4.2.8.4 Arrangements of means of escape.
Assembly occupancies with an occupant load of 500 or more located within a covered mall building shall be so located such that their entrance will be immediately adjacent to a principal entrance to the mall and shall have not less than one-half of their required means of escape opening directly to the exterior of the covered mall building. Assembly occupancies
located within the perimeter line of an open mall building shall be permitted to have their main exit open to the open mall.

4.2.8.4.1 Anchor building means of escape.
Required means of escape for anchor buildings shall be provided independently from the mall means of escape system. The occupant load of anchor buildings opening into the mall shall not be included in determining means of escape requirements for the mall. The path of escape travel of malls shall not exit through anchor buildings. Malls terminating at an anchor building where other means of escape has not been provided shall be considered as a dead-end mall.

4.2.8.5 Distance to exits.
Within each individual tenant space in a covered or open mall building, the distance of travel from any point to an exit or entrance to the mall shall be not greater than 60 960 mm (200 feet).

The distance of travel from any point within a mall of a covered mall building to an exit shall be not greater than 60 960 mm (200 feet). The maximum distance of travel from any point within an open mall to the perimeter line of the open mall building shall be not greater than 60 960 mm (200 feet).

4.2.8.6 Access to exits.
Where more than one exit is required, they shall be so arranged that it is possible to travel in either direction from any point in a mall of a covered mall building to separate exits or from any point in an open mall of an open mall building to two separate locations on the perimeter line, provided that neither location is an exterior wall of an anchor building or parking garage. The width of an exit passageway or corridor from a mall shall be not less than 1676 mm (66 inches).

Exception: Access to exits is permitted by way of a dead-end mall that does not exceed a length equal to twice the width of the mall measured at the narrowest location within the dead-end portion of the mall.

4.2.8.6.1 Exit passageways.
Where exit passageways provide a secondary means of escape from a tenant space, the exit passageways shall be constructed in accordance with this Code.

4.2.8.7 Service areas facing on exit passageways.
Mechanical rooms, electrical rooms, building service areas and service elevators are permitted to open directly into exit passageways, provided that the exit passageway is separated from such rooms with not less than 1-hour fire barriers constructed in accordance with this Code or horizontal assemblies constructed in accordance with this Code. The fire protection rating of openings in the fire barriers shall be not less than 1 hour.

4.2.8.8 Security grilles and doors.
Horizontal sliding or vertical security grilles or doors that are a part of a required means of escape shall conform to the following:

1. Doors and grilles shall remain in the full open position during the period of occupancy by the general public.

2. Doors or grilles shall not be brought to the closed position when there are 10 or more persons occupying spaces served by a single exit or 50 or more persons occupying spaces served by more than one exit.

3. The doors or grilles shall be openable from within without the use of any special knowledge or effort where the space is occupied.

4. Where two or more exits are required, not more than one-half of the exits shall be permitted to include either a horizontal sliding or vertical rolling grille or door.

4.3 HIGH-RISE BUILDINGS

4.3.1 Applicability.
High-rise buildings shall comply with Clauses 4.3.2 through 4.3.6.

Exception: The provisions of Clauses 4.3.2 through 4.3.6 shall not apply to the following buildings and structures:

1. Airport traffic control towers in accordance with Clause 4.12.2.

2. Open parking garages in accordance with Clause 4.6.5.
3. The portion of a building containing a Group A-5 occupancy in accordance with Clause 3.3.6.

4. Special industrial occupancies in accordance with this Code

5. Buildings containing any one of the following:
   5.1. A Group H-1 occupancy.
   5.2. A Group H-2 occupancy in accordance with Clause 4.15.8.
   5.3. A Group H-3 occupancy in accordance with Clause 4.15.8.

4.3.2 Construction.
The construction of high-rise buildings shall comply with the provisions of Clauses 4.3.2.1 through 4.3.2.4.

4.3.2.1 Reduction in fire-resistance rating.
The fire-resistance rating reductions listed in Clauses 4.3.2.1.1 and 4.3.2.1.2 shall be allowed in buildings that have sprinkler control valves equipped with supervisory initiating devices and water-flow initiating devices for each floor.

4.3.2.1.1 Type of construction.
The following reductions in the minimum fire-resistance rating of the building elements in Table 601 shall be permitted as follows:

1. For buildings not greater than 128 m (420 feet) in building height, the fire-resistance rating of the building elements in Type IA construction shall be permitted to be reduced to the minimum fire-resistance ratings for the building elements in Type IB.

   Exception: The required fire-resistance rating of columns supporting floors shall not be reduced.

2. In other than Group F-1, H-2, H-3, H-5, M and S-1 occupancies, the fire-resistance rating of the building elements in Type IB construction shall be permitted to be reduced to the fire-resistance ratings in Type IA.

3. The building height and building area limitations of a building containing building elements with reduced fire-resistance ratings shall be permitted to be the same as the building without such reductions.

4.3.2.1.2 Shaft enclosures.
For buildings not greater than 128 m (420 feet) in building height, the required fire-resistance rating of the fire barriers enclosing vertical shafts, other than interior exit stairway and elevator hoistway enclosures, is permitted to be reduced to 1 hour where automatic sprinklers are installed within the shafts at the top and at alternate floor levels.

4.3.2.2 Seismic considerations.
For seismic considerations, see Part 17

4.3.2.3 Structural integrity of interior exit stairways and elevator hoistway enclosures.
For high-rise buildings of Risk Category III or IV in accordance with this Code and for all buildings that are more than 128 m (420 feet) in building height, enclosures for interior exit stairways and elevator hoistway enclosures shall comply with Clauses 4.3.2.3.1 through 4.3.2.3.4.

4.3.2.3.1 Wall assembly.
The wall assemblies making up the enclosures for interior exit stairways and elevator hoistway enclosures shall meet or exceed Soft Body Impact Classification Level 2 as measured by the test method described in ASTM C1629/C1629M.

4.3.2.3.2 Wall assembly materials.
The face of the wall assemblies making up the enclosures for interior exit stairways and elevator hoistway enclosures that are not exposed to the interior of the enclosures for interior exit stairways or elevator hoistway enclosure shall be constructed in accordance with one of the following methods:
1. The wall assembly shall incorporate not fewer than two layers of impact-resistant construction board each of which meets or exceeds Hard Body Impact Classification Level 2 as measured by the test method described in ASTM C1629/C1629M.

2. The wall assembly shall incorporate not less than one layer of impact-resistant construction material that meets or exceeds Hard Body Impact Classification Level 3 as measured by the test method described in ASTM C1629/C1629M.

3. The wall assembly incorporates multiple layers of any material, tested in tandem that meets or exceeds Hard Body Impact Classification Level 3 as measured by the test method described in ASTM C1629/C1629M.

4.3.2.3 Concrete and masonry walls. Concrete or masonry walls shall be deemed to satisfy the requirements of Clauses 4.3.2.3.1 and 4.3.2.3.2.

4.3.2.4 Other wall assemblies. Any other wall assembly that provides impact resistance equivalent to that required by Clauses 4.3.2.3.1 and 4.3.2.3.2 for Hard Body Impact Classification Level 3, as measured by the test method described in ASTM C1629/C1629M, shall be permitted.

4.3.2.4 Sprayed fire-resistant materials (SFRM). The bond strength of the SFRM installed throughout the building shall be in accordance with Table 4.3.2.4.

**TABLE 4.3.2.4: MINIMUM BOND STRENGTH**

<table>
<thead>
<tr>
<th>HEIGHT OF BUILDING</th>
<th>SFRM MINIMUM BOND STRENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 420 feet</td>
<td>430 psf</td>
</tr>
<tr>
<td>Greater than 420</td>
<td>1,000 psf</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 pound per square foot (psf) = 0.0479 kW/m².

a. Above the lowest level of fire department vehicle access.

4.3.3 Automatic sprinkler system. Buildings and structures shall be equipped throughout with an automatic sprinkler system in accordance with this Code and a secondary water supply where required by Clause 4.3.3.3.

Exception: An automatic sprinkler system shall not be required in spaces or areas of:

1. Open parking garages in accordance with Clause 4.6.5.

2. Telecommunications equipment buildings used exclusively for telecommunications equipment, associated electrical power distribution equipment, batteries and standby engines, provided that those spaces or areas are equipped throughout with an automatic fire detection system in accordance with Clause 10.7.2 and are separated from the remainder of the building by not less than 1-hour fire barriers constructed in accordance with this Code or not less than 2-hour horizontal assemblies constructed in accordance with this Code.

4.3.3.1 Number of sprinkler risers and system design. Each sprinkler system zone in buildings that are more than 128 m (420 feet) in building height shall be supplied by not fewer than two risers. Each riser shall supply sprinklers on alternate floors. If more than two risers are provided for a zone, sprinklers on adjacent floors shall not be supplied from the same riser.

4.3.3.1.1 Riser location. Sprinkler risers shall be placed in interior exit stairways and ramps that are remotely located in accordance with this Code.

4.3.3.2 Water supply to required fire pumps. In buildings that are more than 128 m (420 feet) in building height, required fire pumps shall be supplied by connections to not fewer than two water mains located in different streets.
Separate supply piping shall be provided between each connection to the water main and the pumps. Each connection and the supply piping between the connection and the pumps shall be sized to supply the flow and pressure required for the pumps to operate.

**Exception:** Two connections to the same main shall be permitted provided that the main is valved such that an interruption can be isolated so that the water supply will continue without interruption through not less than one of the connections.

### 4.3.3.3 Secondary water supply.

An automatic secondary on-site water supply having a capacity not less than the hydraulically calculated sprinkler demand, including the hose stream requirement, shall be provided for high-rise buildings assigned to Seismic Design Category 2 or 3 as determined by this Code. An additional fire pump shall not be required for the secondary water supply unless needed to provide the minimum design intake pressure at the suction side of the fire pump supplying the automatic sprinkler system. The secondary water supply shall have a duration of not less than 30 minutes.

### 4.3.3.4 Fire pump room.

Fire pumps shall be located in rooms protected in accordance with this Code.

### 4.3.4 Emergency systems.

The detection, alarm and emergency systems of high-rise buildings shall comply with Clauses 4.3.4.1 through 4.3.4.8.

#### 4.3.4.1 Smoke detection.

Smoke detection shall be provided in accordance with this Code.

#### 4.3.4.2 Fire alarm system.

A fire alarm system shall be provided in accordance with this Code.

#### 4.3.4.3 Fire hydrant system.

A high-rise building shall be equipped with a Fire hydrant system as required by this Code.

#### 4.3.4.4 Emergency voice/alarm communication system.

An emergency voice/alarm communication system shall be provided in accordance with this Code.

#### 4.3.4.5 Emergency responder radio coverage.

Emergency responder radio coverage shall be provided in accordance with the Ghana Fire Code.

#### 4.3.4.6 Fire command.

A fire command center complying with this Code shall be provided in a location approved by the fire Code official.

#### 4.3.4.7 Smoke removal.

To facilitate smoke removal in post-fire salvage and overhaul operations, buildings and structures shall be equipped with natural or mechanical ventilation for removal of products of combustion in accordance with one of the following:

1. Easily identifiable, manually operable windows or panels shall be distributed around the perimeter of each floor at not more than 15 240 mm (50-foot) intervals. The area of operable windows or panels shall be not less than 3.7 m² (40 square feet) per 15 240 mm (50 linear feet) of perimeter.

**Exceptions:**

1. In Group R-1 occupancies, each sleeping unit or suite having an exterior wall shall be permitted to be provided with (0.19 m²) of venting area in lieu of the area specified in Item 1.

2. Windows shall be permitted to be fixed provided that glazing can be cleared by fire fighters.

2. Mechanical air-handling equipment providing one exhaust air change every 15 minutes for the area involved. Return and exhaust air shall be moved directly to the outside without recirculation to other portions of the building.

3. Any other approved design that will produce equivalent results.

#### 4.3.4.8 Standby and emergency power.

A standby power system complying with this Code shall be provided for the standby power loads specified in Clause 4.3.4.8.3. An emergency power system complying with this
78

Code shall be provided for the emergency power loads specified in Clause 4.3.4.8.4.

4.3.4.8.1 Equipment room.

If the standby or emergency power system includes a generator set inside a building, the system shall be located in a separate room enclosed with 2-hour fire barriers constructed in accordance with this Code or horizontal assemblies constructed in accordance with this Code, or both. System supervision with manual start and transfer features shall be provided at the fire command center.

Exception: In Group I-2, Condition 2, manual start and transfer features for the critical branch of the emergency power are not required to be provided at the fire command center.

4.3.4.8.2 Fuel line piping protection.

Fuel lines supplying a generator set inside a building shall be separated from areas of the building other than the room the generator is located in by an approved method or assembly that has a fire-resistance rating of not less than 2 hours. Where the building is protected throughout with an automatic sprinkler system installed in accordance with this Code the required fire-resistance rating shall be reduced to 1 hour.

4.3.4.8.3 Standby power loads.

The following are classified as standby power loads:

1. Ventilation and automatic fire detection equipment for smokeproof enclosures.
2. Elevators.
3. Where elevators are provided in a high-rise building for accessible means of escape, fire service access or occupant self-evacuation, the standby power system shall also comply with this Code, as applicable.

4.3.4.8.4 Emergency power loads.

The following are classified as emergency power loads:

1. Exit signs and means of escape illumination required by Part 11
2. Elevator car lighting.
3. Emergency voice/alarm communications systems.
4. Automatic fire detection systems.
5. Fire alarm systems.
6. Electrically powered fire pumps.
7. Power and lighting for the fire command center required by Clause 4.3.4.6.

4.3.5 Means of escape and evacuation.

The means of escape in high-rise buildings shall comply with Clauses 4.3.5.1 through 4.3.5.6.

4.3.5.1 Remoteness of interior exit stairways.

Required interior exit stairways shall be separated by a distance not less than 9144 mm (30 feet) or not less than one-fourth of the length of the maximum overall diagonal dimension of the building or area to be served, whichever is less. The distance shall be measured in a straight line between the nearest points of the enclosure surrounding the interior exit stairways. In buildings with three or more interior exit stairways, not fewer than two of the interior exit stairways shall comply with this clause. Interlocking or scissor stairways shall be counted as one interior exit stairway.

4.3.5.2 Additional interior exit stairway.

For buildings other than Group R-2 and their ancillary spaces that are more than 128 m (420 feet) in building height, one additional interior exit stairway meeting the requirements of this Code shall be provided in addition to the minimum number of exits required by this Code. The total capacity of any combination of remaining interior exit stairways with one interior exit stairway removed shall be not less than the total capacity required by this Code. Scissor stairways shall not be considered the additional interior exit stairway required by this clause.

Exceptions:
1. An additional interior exit stairway shall not be required to be installed in buildings having elevators used for occupant self-evacuation in accordance with this Code.

2. An additional interior exit stairway shall not be required for other portions of the building where the highest occupiable floor level in those areas is less than 128 m (420 feet) in building height.

4.3.5.3 Stairway door operation.
Stairway doors other than the exit discharge doors shall be permitted to be locked from the stairway side. Stairway doors that are locked from the stairway side shall be capable of being unlocked simultaneously without unlatching upon a signal from the fire command center.

4.3.5.3.1 Stairway communication system.
A telephone or other two-way communications system connected to an approved constantly attended station shall be provided at not less than every fifth floor in each stairway where the doors to the stairway are locked.

4.3.5.4 Smokeproof enclosures.
Every required interior exit stairway serving floors more than 22 860 mm (75 feet) above the lowest level of fire department vehicle access shall be a smokeproof enclosure in accordance with this Code.

4.3.5.5 Luminous escape path markings.
Luminous escape path markings shall be provided in accordance with this Code.

4.3.5.6 Emergency escape and rescue.
Emergency escape and rescue openings specified in this Code are not required.

4.3.6 Elevators.
Elevator installation and operation in high-rise buildings shall comply with Part 31 and Clauses 4.3.6.1 and 4.3.6.2.

4.3.6.1 Fire service access elevator.
In buildings with an occupied floor more than 36 576 mm (120 feet) above the lowest level of fire department vehicle access, not fewer than two fire service access elevators, or all elevators, whichever is less, shall be provided in accordance with this Code. Each fire service access elevator shall have a capacity of not less than 1588 kg (3,500 pounds) and shall comply with this Code.

4.3.6.2 Occupant evacuation elevators.
Where installed in accordance with this Code, passenger elevators for general public use shall be permitted to be used for occupant self-evacuation.

4.4 ATRIUMS

4.4.1 General.
In other than Group H occupancies, and where permitted by this Code the provisions of Clauses 4.4.1 through 4.4.10 shall apply to buildings or structures containing vertical openings defined as “Atriums.”

4.4.2 Use.
The floor of the atrium shall not be used for other than low fire hazard uses and only approved materials and decorations in accordance with the Ghana Fire Code shall be used in the atrium space.

Exception: The atrium floor area is permitted to be used for any approved use where the individual space is provided with an automatic sprinkler system in accordance with this Code.

4.4.3 Automatic sprinkler protection.
An approved automatic sprinkler system shall be installed throughout the entire building.

Exceptions:

1. That area of a building adjacent to or above the atrium need not be sprinklered provided that portion of the building is separated from the atrium portion by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with this Code.

2. Where the ceiling of the atrium is more than 16 764 mm (55 feet) above the floor, sprinkler protection at the ceiling of the atrium is not required.

4.4.4 Fire alarm system.
A fire alarm system shall be provided in accordance with this Code.
4.4.5 Smoke control.
A smoke control system shall be installed in accordance with this Code.

Exception: In other than Group I-2, and Group I-1, Condition 2, smoke control is not required for atriums that connect only two stories.

4.4.6 Enclosure of atriums.
Atrium spaces shall be separated from adjacent spaces by a 1-hour fire barrier constructed in accordance with this Code or a horizontal assembly constructed in accordance with this Code.

Exceptions:

1. A fire barrier is not required where a glass wall forming a smoke partition is provided. The glass wall shall comply with all of the following:

   1.1. Automatic sprinklers are provided along both sides of the separation wall and doors, or on the room side only if there is not a walkway on the atrium side. The sprinklers shall be located between 102 mm and 305 mm (4 inches and 12 inches) away from the glass and at intervals along the glass not greater than 1829 mm (6 feet). The sprinkler system shall be designed so that the entire surface of the glass is wet upon activation of the sprinkler system without obstruction;

   1.2. The glass wall shall be installed in a gasketed frame in a manner that the framing system deflects without breaking (loading) the glass before the sprinkler system operates; and

   1.3. Where glass doors are provided in the glass wall, they shall be either self-closing or automatic-closing.

2. A fire barrier is not required where a glass-block wall assembly complying with this Code and having a 3/4-hour fire protection rating is provided.

3. A fire barrier is not required between the atrium and the adjoining spaces of up to three floors of the atrium provided that such spaces are accounted for in the design of the smoke control system.

4. A fire barrier is not required between the atrium and the adjoining spaces where the atrium is not required to be provided with a smoke control system.

4.4.7 Standby power.
Equipment required to provide smoke control shall be provided with standby power in accordance with this Code.

4.4.8 Interior finish.
The interior finish of walls and ceilings of the atrium shall be not less than Class B. Sprinkler protection shall not result in a reduction in class.

4.4.9 Exit access travel distance.
Exit access travel distance for areas open to an atrium shall comply with the requirements of this clause.

4.4.9.1 Escape not through the atrium.
Where required access to the exits is not through the atrium, exit access travel distance shall comply with this Code.

4.4.9.2 Exit access travel distance at the level of exit discharge.
Where the path of escape travel is through an atrium space, exit access travel distance at the level of exit discharge shall be determined in accordance with this Code.

4.4.9.3 Exit access travel distance at other than the level of exit discharge.
Where the path of escape travel is not at the level of exit discharge from the atrium, that portion of the total permitted exit access travel distance that occurs within the atrium shall be not greater than 60 960 mm (200 feet).

4.4.10 Interior exit stairways.
Not greater than 50 percent of interior exit stairways are permitted to escape through an...
atrium on the level of exit discharge in accordance with this Code.

4.5 UNDERGROUND BUILDINGS

4.5.1 General.
The provisions of Clauses 4.5.2 through 4.5.9 apply to building spaces having a floor level used for human occupancy more than 9144 mm (30 feet) below the finished floor of the lowest level of exit discharge.

Exceptions: The provisions of Clause 4.5 are not applicable to the following buildings or portions of buildings:

1. One- and two-family dwellings, sprinklered in accordance with this Code
2. Parking garages provided with automatic sprinkler systems in compliance with Clause 4.5.3.
3. Fixed guideway transit systems.
4. Grandstands, bleachers, stadiums, arenas and similar facilities.
5. Where the lowest storey is the only storey that would qualify the building as an underground building and has an area not greater than 139 m$^2$ (1,500 square feet) and has an occupant load less than 10.
6. Pumping stations and other similar mechanical spaces intended only for limited periodic use by service or maintenance personnel.

4.5.2 Construction requirements.
The underground portion of the building shall be of Type I construction.

4.5.3 Automatic sprinkler system.
The highest level of exit discharge serving the underground portions of the building and all levels below shall be equipped with an automatic sprinkler system installed in accordance with this Code Water-flow switches and control valves shall be supervised in accordance with this Code.

4.5.4 Compartmentation.
Compartmentation shall be in accordance with Clauses 4.5.4.1 through 4.5.4.3.

4.5.4.1 Number of compartments.
A building having a floor level more than 18 288 mm (60 feet) below the finished floor of the lowest level of exit discharge shall be divided into not fewer than two compartments of approximately equal size. Such compartmentation shall extend through the highest level of exit discharge serving the underground portions of the building and all levels below.

Exception: The lowest storey need not be compartmented where the area is not greater than 139 m$^2$ (1,500 square feet) and has an occupant load of less than 10.

4.5.4.2 Smoke barrier penetration.
The compartments shall be separated from each other by a smoke barrier in accordance with Clause 709. Penetrations between the two compartments shall be limited to plumbing and electrical piping and conduit that are firestopped in accordance with this Code. Doorways shall be protected by fire door assemblies that comply with this Code automatic-closing by smoke detection in accordance with this Code and installed in accordance with this Code. Where provided, each compartment shall have an air supply and an exhaust system independent of the other compartments.

4.5.4.3 Elevators.
Where elevators are provided, each compartment shall have direct access to an elevator. Where an elevator serves more than one compartment, an enclosed elevator lobby shall be provided and shall be separated from each compartment by a smoke barrier in accordance with this Code. Doorways in the smoke barrier shall be protected by fire door assemblies that comply with this Code.

4.5.5 Smoke control system.
A smoke control system shall be provided in accordance with Clauses 4.5.5.1 and 4.5.5.2.

4.5.5.1 Control system.
A smoke control system is required to control the migration of products of combustion in accordance with this Code and the provisions of this clause. Smoke control shall restrict
movement of smoke to the general area of fire origin and maintain means of escape in a usable condition.

4.5.5.2 Compartment smoke control system. Where compartmentation is required, each compartment shall have an independent smoke control system. The system shall be automatically activated and capable of manual operation in accordance with this Code

4.5.6 Fire alarm systems. A fire alarm system shall be provided where required by this Code.

4.5.7 Means of escape. Means of escape shall be in accordance with this Code.

4.5.7.1 Number of exits. Each floor level shall be provided with no fewer than two exits. Where compartmentation is required by Clause 4.5.4, each compartment shall have not fewer than one exit and not less than one exit access doorway into the adjoining compartment.

4.5.7.2 Smokeproof enclosure. Every required stairway serving floor levels more than 9144 mm (30 feet) below the finished floor of its level of exit discharge shall comply with the requirements for a smokeproof enclosure as provided in this Code.

4.5.8 Standby and emergency power. A standby power system complying with this Code shall be provided for the standby power loads specified in Clause 4.5.8.1. An emergency power system complying with this Code shall be provided for the emergency power loads specified in Clause 4.5.8.2.

4.5.8.1 Standby power loads. The following are classified as standby power loads:

   1. Smoke control system.
   2. Ventilation and automatic fire detection equipment for smokeproof enclosures.
   3. Elevators, as required in this Code

4.5.8.2 Emergency power loads. The following are classified as emergency power loads:

   1. Emergency voice/alarm communications systems.
   2. Fire alarm systems.
   3. Automatic fire detection systems.
   4. Elevator car lighting.
   5. Means of escape and exit sign illumination as required by Part 11.
   6. Fire pumps.

4.5.9 Fire hydrant system. The underground building shall be equipped throughout with a Fire hydrant system in accordance with this Code.

4.6 MOTOR-VEHICLE-RELATED OCCUPANCIES

4.6.1 General. All motor-vehicle-related occupancies shall comply with Clause 4.6.2. Private garages and carports shall also comply with Clause 4.6.3. Open public parking garages shall also comply with Clauses 4.6.4 and 4.6.5. Enclosed public parking garages shall also comply with Clauses 4.6.4 and 4.6.6. Motor fuel-dispensing facilities shall also comply with Clause 4.6.7. Repair garages shall also comply with Clause 4.6.8.

4.6.2 Design. Private garages and carports, open and enclosed public parking garages, motor fuel-dispensing facilities and repair garages shall comply with Clauses 4.6.2.1 through 4.6.2.8.

4.6.2.1 Automatic garage door openers and vehicular gates. Automatic garage door openers shall be listed and labeled in accordance with this Code. Where provided, automatic vehicular gates shall comply with this Code.

4.6.2.2 Clear height. The clear height of each floor level in vehicle and pedestrian traffic areas shall be not less than 2134 mm (7 feet). Canopies under which fuels are dispensed shall have a clear height in accordance with Clause 4.6.7.2.

   Exception: A lower clear height is permitted for a parking tier in mechanical-access open parking garages where approved by the building official.

4.6.2.3 Accessible parking spaces. Where parking is provided, accessible parking spaces, access aisles and vehicular routes
serving accessible parking shall be provided in accordance with this Code.

4.6.2.4 Floor surfaces.

Floor surfaces shall be of concrete or similar approved noncombustible and nonabsorbent materials. The area of floor used for the parking of automobiles or other vehicles shall be sloped to facilitate the movement of liquids to a drain or toward the main vehicle entry doorway. The surface of vehicle fueling pads in motor fuel-dispensing facilities shall be in accordance with Clause 4.6.7.1.

Exceptions:

1. Asphalt parking surfaces shall be permitted at ground level for public parking garages and private carports.

2. Floors of Group S-2 parking garages shall not be required to have a sloped surface.

3. Slip-resistant, nonabsorbent, interior floor finishes having a critical radiant flux not more than 0.45 W/cm², as determined by ASTM E648 shall be permitted in repair garages.

4.6.2.5 Sleeping rooms.

Openings between a motor vehicle-related occupancy and a room used for sleeping purposes shall not be permitted.

4.6.2.6 Fuel dispensing.

The dispensing of fuel shall only be permitted in motor fuel-dispensing facilities in accordance with Clause 4.6.7.

4.6.2.7 Mixed occupancies and uses.

Mixed uses shall be allowed in the same building as public parking garages and repair garages in accordance with Clause 6.11.1. Mixed uses in the same building as an open parking garage are subject to Clauses 4.2.4.2.3, 4.6.5.11, 6.11.1, 6.13.3, 6.13.4 and 6.13.7.

4.6.2.8 Equipment and appliances.

Equipment and appliances shall be installed in accordance with Clauses 4.6.2.8.1 through 4.6.2.8.3.

4.6.2.8.1 Elevation of ignition sources.

Equipment and appliances having an ignition source and located in hazardous locations and public garages, private garages, repair garages, automotive motor fuel-dispensing facilities and parking garages shall be elevated such that the source of ignition is not less than 457 mm (18 inches) above the floor surface on which the equipment or appliance rests. For the purpose of this clause, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exception: Elevation of the ignition source is not required for appliances that are listed as flammable vapour ignition resistant.

4.6.2.8.1.1 Parking garages.

Connection of a parking garage with any room in which there is a fuel-fired appliance shall be by means of a vestibule providing a two-doorway separation, except that a single door is permitted where the sources of ignition in the appliance are elevated in accordance with Clause 4.6.2.8.

Exception: This clause shall not apply to appliance installations complying with Clause 4.6.2.8.2 or 4.6.2.8.3.

4.6.2.8.2 Public garages.

Appliances located in public garages, motor fuel-dispensing facilities, repair garages or other areas frequented by motor vehicles shall be installed not less than 2438 mm (8 feet) above the floor. Where motor vehicles are capable of passing under an appliance, the appliance shall be installed at the clearances required by the appliance manufacturer and not less than 305 mm (1 foot) higher than the tallest vehicle garage door opening.

Exception: The requirements of this clause shall not apply where the appliances are protected from motor vehicle impact and installed in accordance with Clause 4.6.2.8.1.

4.6.2.8.3 Private garages.

Appliances located in private garages and


4.6.3 Private garages and carports.

Private garages and carports shall comply with Clauses 4.6.2 and 4.6.3, or they shall comply with Clauses 4.6.2 and 4.6.4.

4.6.3.1 Classification.

Private garages and carports shall be classified as Group U occupancies. Each private garage shall be not greater than $93 \text{ m}^2$ (1,000 square feet) in area. Multiple private garages are permitted in a building where each private garage is separated from the other private garages by 1-hour fire barriers in accordance with this Code or 1-hour horizontal assemblies in accordance with this Code.

4.6.3.2 Separation.

For other than private garages adjacent to dwelling units, the separation of private garages from other occupancies shall comply with Clause 6.11. Separation of private garages from dwelling units shall comply with Clauses 4.6.3.2.1 and 4.6.3.2.2.

4.6.3.2.2 Ducts.

Ducts in a private garage and ducts penetrating the walls or ceilings separating the dwelling unit from the garage, including its attic area, shall be constructed of sheet steel of not less than 0.48 mm (0.019 inch) in thickness and shall not have openings into the garage.

4.6.3.3 Carports.

Carports shall be open on not fewer than two sides. Carports open on fewer than two sides shall be considered to be a garage and shall comply with the requirements for private garages.

4.6.3.3.1 Carport separation.

A separation is not required between a Group R-3 and U carport, provided that the carport is entirely open on two or more sides and there are not enclosed areas above.

4.6.4 Public parking garages.

Parking garages, other than private garages, shall be classified as public parking garages and shall comply with the provisions of Clauses 4.6.2 and 4.6.4 and shall be classified as either an open parking garage or an enclosed parking garage. Open parking garages shall also comply with Clause 4.6.5. Enclosed parking garages shall also comply with Clause 4.6.6.

4.6.4.1 Guards.

Guards shall be provided in accordance with this Code. Guards serving as vehicle barriers shall comply with Clauses 4.6.4.2 and Clause 11.15.

4.6.4.2 Vehicle barriers.

Vehicle barriers not less than 835 mm (2 feet 9 inches) in height shall be placed where the vertical distance from the floor of a drive lane or parking space to the ground or surface directly below is greater than 305 mm (1 foot). Vehicle barriers shall comply with the loading requirements of this Code.

Exception: Vehicle barriers are not required in vehicle storage compartments in a mechanical access parking garage.

4.6.4.3 Ramps.

Vehicle ramps shall not be considered as required exits unless pedestrian facilities are provided. Vehicle ramps that are utilized for vertical circulation as well as for parking shall not exceed a slope of 1:15 (6.67 percent).

4.6.5 Open parking garages.

Open parking garages shall comply with Clauses 4.6.2, 4.6.4 and 4.6.5.

4.6.5.1 Construction.

Open parking garages shall be of Type I or III construction. Open parking garages shall meet the design requirements of Part 17. For vehicle barriers, see Clause 4.6.4.2.

4.6.5.2 Openings.

For natural ventilation purposes, the exterior side of the structure shall have uniformly distributed openings on two or more sides. The area of such openings in exterior walls on a tier shall be not less than 20 percent of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall be not less than 40 percent of the perimeter of the tier.
Interior walls shall be not less than 20 percent open with uniformly distributed openings.

**Exception:** Openings are not required to be distributed over 40 percent of the building perimeter where the required openings are uniformly distributed over two opposing sides of the building.

### 4.6.5.2.1 Openings below grade.

Where openings below grade provide required natural ventilation, the outside horizontal clear space shall be one and one-half times the depth of the opening. The width of the horizontal clear space shall be maintained from grade down to the bottom of the lowest required opening.

### 4.6.5.3 Mixed occupancies and uses.

Mixed uses shall be allowed in the same building as an open parking garage subject to the provisions of Clauses 4.2.4.2.3, 4.6.5.11, 6.11.1, 6.13.3, 6.13.4 and 6.13.7.

### 4.6.5.4 Area and height.

Area and height of open parking garages shall be limited as set forth in Part 6 for Group S-2 occupancies and as further provided for in Clause 6.11.1.

#### TABLE 4.6.5.4

<table>
<thead>
<tr>
<th>TYPE OF CONSTRUCTION</th>
<th>AREA PER TIER (square feet)</th>
<th>HEIGHT (in tiers)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ramp access</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unlimited</td>
</tr>
<tr>
<td>IA</td>
<td>Unlimited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>IB</td>
<td>Unlimited</td>
<td>10 tiers</td>
</tr>
<tr>
<td>IIA</td>
<td>50,000</td>
<td>8 tiers</td>
</tr>
<tr>
<td>IIB</td>
<td>50,000</td>
<td>4 tiers</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.0929 m².

### 4.6.5.4.1 Single use.

Where the open parking garage is used exclusively for the parking or storage of private motor vehicles, and the building is without other uses, the area and height shall be permitted to comply with Table 4.6.5.4, along with increases allowed by Clause 4.6.5.5.

**Exception:** The grade-level tier is permitted to contain an office, waiting and toilet rooms having a total combined area of not more than 93 m² (1,000 square feet). Such area need not be separated from the open parking garage.

In open parking garages having a spiral or sloping floor, the horizontal projection of the structure at any cross clause shall not exceed the allowable area per parking tier. In the case of an open parking garage having a continuous spiral floor, each 2896 mm (9 feet 6 inches) of height, or portion thereof, shall be considered under these provisions to be a tier.

### 4.6.5.5 Area and height increases.

The allowable area and height of open parking garages shall be increased in accordance with the provisions of this clause. Garages with sides open on three-fourths of the building’s perimeter are permitted to be increased by 25 percent in area and one tier in height. Garages with sides open around the entire building’s perimeter are permitted to be increased by 50 percent in area and one tier in height. For a side to be considered open under these provisions, the total area of openings along the side shall be not less than 50 percent of the interior area of the side at each tier and such openings shall be equally distributed along the length of the tier. For purposes of calculating the interior area of the side, the height shall not exceed 2134 mm (7 feet).

Allowable tier areas in Table 4.6.5.4 shall be increased for open parking garages constructed to heights less than the table maximum. The gross tier area of the garage shall not exceed that permitted for the higher
structure. Not fewer than three sides of each such larger tier shall have continuous horizontal openings not less than 762 mm (30 inches) in clear height extending for not less than 80 percent of the length of the sides. All parts of such larger tier shall be not more than 60 960 mm (200 feet) horizontally from such an opening. In addition, each such opening shall face a street or yard accessible to a street with a width of not less than 9144 mm (30 feet) for the full length of the opening, and standpipes shall be provided in each such tier.

Open parking garages of Type I construction, with all sides open, shall be unlimited in allowable area where the building height does not exceed 22 860 mm (75 feet). For a side to be considered open, the total area of openings along the side shall be not less than 50 percent of the interior area of the side at each tier and such openings shall be equally distributed along the length of the tier. For purposes of calculating the interior area of the side, the height shall not exceed 2134 mm (7 feet). All portions of tiers shall be within 60 960 mm (200 feet) horizontally from such openings or other natural ventilation openings as defined in Clause 4.6.5.2. These openings shall be permitted to be provided in courts with a minimum dimension of 6096 mm (20 feet) for the full width of the openings.

4.6.5.6 Fire separation distance.

Exterior walls and openings in exterior walls shall comply with Tables 7.1 and 7.2. The distance to an adjacent plot line shall be determined in accordance with Table 7.2 and Clause 8.5.

4.6.5.7 Means of escape.

Where persons other than parking attendants are permitted, open parking garages shall meet the means of escape requirements of Part 11. Where persons other than parking attendants are not permitted, there shall be not fewer than two exit stairways. Each exit stairway shall be not less than 914 mm (36 inches) in width. Lifts shall be permitted to be installed for use of employees only, provided that they are completely enclosed by noncombustible materials.

4.6.5.8 Fire hydrant system.

An open parking garage shall be equipped with a Fire hydrant system as required by Clause 10.5.3.

4.6.5.9 Enclosure of vertical openings.

Enclosure shall not be required for vertical openings except as specified in Clause 4.6.5.7.

4.6.5.10 Ventilation.

Ventilation, other than the percentage of openings specified in Clause 4.6.5.2, shall not be required.

4.6.5.11 Prohibitions.

The following uses and alterations are not permitted:

1. Vehicle repair work.
2. Parking of buses, trucks and similar vehicles.
3. Partial or complete closing of required openings in exterior walls by tarpaulins or any other means.
4. Dispensing of fuel.

4.6.6 Enclosed parking garages.

Enclosed parking garages shall comply with Clauses 4.6.2, 4.6.4 and 4.6.6.

4.6.6.1 Heights and areas.

Enclosed vehicle parking garages and portions thereof that do not meet the definition of open parking garages shall be limited to the allowable heights and areas specified in Clause 6.4 and 6.9 as modified by Clause 6.10. Roof parking is permitted.

4.6.6.2 Ventilation.

A mechanical ventilation system and exhaust system shall be provided in accordance with this Code.

Exception: Mechanical ventilation shall not be required for enclosed parking garages that are accessory to one- and two-family dwellings.

4.6.6.3 Automatic sprinkler system.

An enclosed parking garage shall be equipped with an automatic sprinkler system in accordance with Clause 10.3.2.10.

4.6.7 Motor fuel-dispensing facilities.

Motor fuel-dispensing facilities shall comply with the Ghana Fire Code and Clauses 4.6.2 and 4.6.7.
4.6.7.2 Canopies.

Canopies under which fuels are dispensed shall have a clear, unobstructed height of not less than 4115 mm (13 feet 6 inches) to the lowest projecting element in the vehicle drive-through area. Canopies and their supports over pumps shall be of noncombustible materials, fire-retardant-treated wood complying with Part 24, heavy timber complying with this Code or construction providing 1-hour fire resistance. Combustible materials used in or on a canopy shall comply with one of the following:

1. Shielded from the pumps by a noncombustible element of the canopy, or heavy timber complying with Clause 24.4.11.

2. Plastics covered by aluminum facing having a thickness of not less than 0.30 mm (0.010 inch) or corrosion-resistant steel having a base metal thickness of not less than 0.41 mm (0.016 inch). The plastic shall have a flame spread index of 25 or less and a smoke-developed index of 450 or less when tested in the form intended for use in accordance with ASTM E84 and a self-ignition temperature of 343°C (650°F) or greater when tested in accordance with ASTM D1929.

3. Panels constructed of light-transmitting plastic materials shall be permitted to be installed in canopies erected over motor vehicle fuel-dispensing station fuel dispensers, provided that the panels are located not less than 3048 mm (10 feet) from any building on the same plot and face yards or streets not less than 12192 mm (40 feet) in width on the other sides. The aggregate areas of plastics shall be not greater than 93 m² (100 square feet).

4.6.7.2.1 Canopies used to support gaseous hydrogen systems.

Canopies that are used to shelter dispensing operations where flammable compressed gases are located on the roof of the canopy shall be in accordance with the following:

1. The canopy shall meet or exceed Type I construction requirements.

2. Operations located under canopies shall be limited to refueling only.

3. The canopy shall be constructed in a manner that prevents the accumulation of hydrogen gas.

4.6.8 Repair garages.

Repair garages shall be constructed in accordance with the Ghana Fire Code and Clauses 4.6.2 and 4.6.8. This occupancy shall not include motor fuel-dispensing facilities, as regulated in Clause 4.6.7.

4.6.8.1 Ventilation.

Repair garages shall be mechanically ventilated in accordance with the International Mechanical Code. The ventilation system shall be controlled at the entrance to the garage.

4.6.8.2 Gas detection system.

Repair garages used for repair of vehicles fueled by nonodorized gases including but not limited to hydrogen and nonodorized LNG, shall be provided with a gas detection system that complies with Clause 10.16. The gas detection system shall be designed to detect leakage of nonodorized gaseous fuel. Where lubrication or chassis service pits are provided in garages used for repairing nonodorized LNG-fueled vehicles, gas sensors shall be provided in such pits.

4.6.8.2.1 System activation.

Activation of a gas detection alarm shall result in all of the following:

1. Initiation of distinct audible and visual alarm signals in the repair garage, where the ventilation system is interlocked with gas detection.

2. Deactivation of all heating systems located in the repair garage.

3. Activation of the mechanical ventilation system, where the
4.6.8.2.2 Failure of the gas detection system.
Failure of the gas detection system shall automatically deactivate the heating system, activate the mechanical ventilation system where the system is interlocked with the gas detection system, and cause a trouble signal to sound at an approved location.

4.6.8.3 Automatic sprinkler system.
A repair garage shall be equipped with an automatic sprinkler system in accordance with this Code.

4.7 GROUP I-2

4.7.1 General.
Occupancies in Group I-2 shall comply with the provisions of Clauses 4.7.1 through 4.7.11 and other applicable provisions of this Code.

4.7.2 Corridors continuity and separation.
Corridors in occupancies in Group I-2 shall be continuous to the exits and shall be separated from other areas in accordance with Clause 4.7.3 except spaces conforming to Clauses 4.7.2.1 through 4.7.2.6.

4.7.2.1 Waiting and similar areas.
Waiting areas, public-use areas or group meeting spaces constructed as required for corridors shall be permitted to be open to a corridor, only where all of the following criteria are met:

1. The spaces are not occupied as care recipient’s sleeping rooms, treatment rooms, incidental uses in accordance with Clause 6.12, or hazardous uses.
2. The open space is protected by an automatic fire detection system installed in accordance with Clause 10.7.
3. The corridors onto which the spaces open, in the same smoke compartment, are protected by an automatic fire detection system installed in accordance with Clause 907, or the smoke compartment in which the spaces are located is equipped throughout with quick-response sprinklers in accordance with this Code.
4. The space is arranged so as not to obstruct access to the required exits.

4.7.2.2 Care providers’ stations.
Spaces for care providers’, supervisory staff, doctors’ and nurses’ charting, communications and related clerical areas shall be permitted to be open to the corridor, where such spaces are constructed as required for corridors.

4.7.2.3 Psychiatric treatment areas.
Areas wherein psychiatric care recipients who are not capable of self-preservation are housed, or group meeting or multipurpose therapeutic spaces other than incidental uses in accordance with Clause 6.12, under continuous supervision by facility staff, shall be permitted to be open to the corridor, where the following criteria are met:

1. Each area does not exceed 140 m² (1,500 square feet).
2. The area is located to permit supervision by the facility staff.
3. The area is arranged so as not to obstruct any access to the required exits.
4. The area is equipped with an automatic fire detection system installed in accordance with this Code.
5. Not more than one such space is permitted in any one smoke compartment.
6. The walls and ceilings of the space are constructed as required for corridors.

4.7.2.4 Gift shops.
Gift shops and associated storage that are less than 455 m² (500 square feet) in area shall be permitted to be open to the corridor where such spaces are constructed as required for corridors.
4.7.2.5 Nursing home housing units.

In Group I-2, Condition 1 occupancies, in areas where nursing home residents are housed, shared living spaces, group meeting or multipurpose therapeutic spaces shall be permitted to be open to the corridor, where all of the following criteria are met:

1. The walls and ceilings of the space are constructed as required for corridors.
2. The spaces are not occupied as resident sleeping rooms, treatment rooms, incidental uses in accordance with this Code or hazardous uses.
3. The open space is protected by an automatic fire detection system installed in accordance with this Code.
4. The corridors onto which the spaces open, in the same smoke compartment, are protected by an automatic fire detection system installed in accordance with this Code or the smoke compartment in which the spaces are located is equipped throughout with quick-response sprinklers in accordance with this Code.
5. The space is arranged so as not to obstruct access to the required exits.

4.7.2.6 Nursing home cooking facilities.

In Group I-2, Condition 1 occupancies, rooms or spaces that contain a cooking facility with domestic cooking appliances shall be permitted to be open to the corridor where all of the following criteria are met:

1. The number of care recipients housed in the smoke compartment shall not be greater than 30.
2. The number of care recipients served by the cooking facility shall not be greater than 30.
3. Not more than one cooking facility area shall be permitted in a smoke compartment.
4. The types of domestic cooking appliances permitted shall be limited to ovens, cooktops, ranges, warmers and microwaves.
5. The corridor shall be a clearly identified space delineated by construction or floor pattern, material or color.
6. The space containing the domestic cooking facility shall be arranged so as not to obstruct access to the required exit.
7. Domestic cooking hoods installed and constructed in accordance with this Code shall be provided over cooktops and ranges.
8. Cooktops and ranges shall be protected in accordance with Clause 10.4.13.
9. A shut-off for the fuel and electrical power supply to the cooking equipment shall be provided in a location that is accessible only to staff.
10. A timer shall be provided that automatically deactivates the cooking appliances within a period of not more than 120 minutes.
11. A portable fire extinguisher shall be provided. Installation shall be in accordance with Clause 10.6, and the extinguisher shall be located within a 9144 mm (30-foot) distance of travel from each domestic cooking appliance.

4.7.3 Corridor wall construction.

Corridor walls shall be constructed as smoke partitions in accordance with this Code.

4.7.3.1 Corridor doors.

Corridor doors, other than those in a wall required to be rated by Clause 6.12.4 or for the enclosure of a vertical opening or an exit, shall not have a required fire protection rating and shall not be required to be equipped with self-closing or automatic-closing devices, but shall provide an effective barrier to limit the transfer of smoke and shall be equipped with positive latching. Roller latches are not permitted. Other doors shall conform to Clause 8.16.
4.7.4 Means of escape.

Group I-2 occupancies shall be provided with means of escape complying with Part 11 and Clauses 4.7.4.1 through 4.7.4.4. The fire safety and evacuation plans provided in accordance with Clause 11.2.2 shall identify the building components necessary to support a defend-in-place emergency response in accordance with Clauses 4.3 and 4.4 of the Ghana Fire Code.

4.7.4.1 Direct access to a corridor.
Habitable rooms in Group I-2 occupancies shall have an exit access door leading directly to a corridor.

Exceptions:
1. Rooms with exit doors opening directly to the outside at ground level.
2. Rooms arranged as care suites complying with Clause 4.7.4.4.

4.7.4.1.1 Locking devices.
Locking devices that restrict access to a care recipient’s room from the corridor and that are operable only by staff from the corridor side shall not restrict the means of escape from the care recipient’s room.

Exceptions:
1. This clause shall not apply to rooms in psychiatric treatment and similar care areas.
2. Locking arrangements in accordance with Clause 11.10.1.9.7.

4.7.4.2 Distance of travel.
The distance of travel between any point in a Group I-2 occupancy sleeping room, not located in a care suite, and an exit access door in that room shall be not greater than 15240 mm (50 feet).

4.7.4.3 Projections in nursing home corridors.
In Group I-2, Condition 1 occupancies, where the corridor width is not less than 2440 mm (96 inches), projections shall be permitted for furniture where all of the following criteria are met:

1. The furniture is attached to the floor or to the wall.
2. The furniture does not reduce the clear width of the corridor to less than 1830 mm (72 inches) except where other encroachments are permitted in accordance with Clause 11.5.7.
3. The furniture is positioned on only one side of the corridor.
4. Each arrangement of furniture is 4.6 m² (50 square feet) maximum in area.
5. Furniture arrangements are separated by 3048 mm (10 feet) minimum.
6. Placement of furniture is considered as part of the fire and safety plans in accordance with Clause 11.2.2.

4.7.4.4 Group I-2 care suites.
Care suites in Group I-2 shall comply with Clauses 4.7.4.4.1 through 4.7.4.4.4 and either Clause 4.7.4.4.5 or 4.7.4.4.6.

4.7.4.4.1 Exit access through care suites.
Exit access from all other portions of a building not classified as a care suite shall not pass through a care suite. In a care suite required to have more than one exit, one exit access is permitted to pass through an adjacent care suite provided that all of the other requirements of Clauses 4.7.4 and 11.16.2 are satisfied.

4.7.4.4.2 Separation.
Care suites shall be separated from other portions of the building, including other care suites, by a smoke partition complying with this Code.

4.7.4.4.3 Access to corridor.
Movement from habitable rooms shall not require passage through more than three doors and 30480 mm (100 feet) distance of travel within the suite.

Exception: The distance of travel shall be permitted to be increased to 38100 mm (125 feet) where an automatic smoke detection system is provided throughout the care suite and installed in accordance with this Code.
4.7.4.4 Doors within care suites.
Doors in care suites serving habitable rooms shall be permitted to comply with one of the following:

1. Manually operated horizontal sliding doors permitted in accordance with this Code.

2. Power-operated doors permitted in accordance with this Code.


4.7.4.4.5 Care suites containing sleeping room areas.
Sleeping rooms shall be permitted to be grouped into care suites where one of the following criteria is met:

1. The care suite is not used as an exit access for more than eight care recipient beds.

2. The arrangement of the care suite allows for direct and constant visual supervision into the sleeping rooms by care providers.

3. An automatic smoke detection system is provided in the sleeping rooms and installed in accordance with the Ghana Fire Code.

4.7.4.4.6.2 Exit access.
Care suites, other than sleeping rooms, with an area of more than 232 m² (2,500 square feet) shall have not fewer than two exit access doors from the care suite located in accordance with this Code.

4.7.5 Smoke barriers.
Smoke barriers shall be provided to subdivide every storey used by persons receiving care, treatment or sleeping into not fewer than two smoke compartments. Smoke barriers shall be provided to subdivide other stories with an occupant load of 50 or more persons, into not fewer than two smoke compartments. The smoke barrier shall be in accordance with this Code.

4.7.5.1 Smoke compartment size.
Stories shall be divided into smoke compartments with an area of not more than 2092 m² (22,500 square feet) in Group I-2 occupancies.

Exceptions:

1. A smoke compartment in Group I-2, Condition 2 is permitted to have an area of not more than 3716 m² (40,000 square feet) provided that all patient sleeping rooms within that smoke compartment are configured for single patient occupancy and any suite within the smoke compartment complies with Clause 4.7.4.4.
2. A smoke compartment in Group I-2, Condition 2 without patient sleeping rooms is permitted to have an area of not more than 3716 m$^2$ (40,000 square feet).

4.7.5.2 Exit access travel distance.
The distance of travel from any point in a smoke compartment to a smoke barrier door shall be not greater than 60 960 mm (200 feet).

4.7.5.3 Refuge area.
Refuge areas shall be provided within each smoke compartment. The size of the refuge area shall accommodate the occupants and care recipients from the adjoining smoke compartment. Where a smoke compartment is adjoined by two or more smoke compartments, the minimum area of the refuge area shall accommodate the largest occupant load of the adjoining compartments. The size of the refuge area shall provide the following:

1. Not less than 2.8 m$^2$ (30 net square feet) for each care recipient confined to bed or stretcher.
2. Not less than 0.56 m$^2$ (6 square feet) for each ambulatory care recipient not confined to bed or stretcher and for other occupants.

Areas or spaces permitted to be included in the calculation of refuge area are corridors, sleeping areas, treatment rooms, lounge or dining areas and other low-hazard areas.

4.7.5.4 Independent escape.
A means of escape shall be provided from each smoke compartment created by smoke barriers without having to return through the smoke compartment from which means of escape originated. Smoke compartments that do not contain an exit shall be provided with direct access to not less than two adjacent smoke compartments.

4.7.5.5 Horizontal assemblies.
Horizontal assemblies supporting smoke barriers required by this clause shall be designed to resist the movement of smoke. Elevator lobbies shall be in accordance with this Code.

4.7.6 Automatic-closing doors.
Automatic-closing doors with hold-open devices shall comply with Clauses 8.9.5 and 8.16.2.

4.7.7 Automatic sprinkler system.
Smoke compartments containing sleeping rooms shall be equipped throughout with an automatic sprinkler system in accordance with Clauses 10.3.3.1.1 and 10.3.3.2.

4.7.8 Fire alarm system.
A fire alarm system shall be provided in accordance with Clause 10.7.2.6.

4.7.9 Automatic fire detection.
Corridors in Group I-2, Condition 1 occupancies and spaces permitted to be open to the corridors by Clause 4.7.2 shall be equipped with an automatic fire detection system.

Group I-2, Condition 2 occupancies shall be equipped with smoke detection as required in Clause 407.2.

Exceptions:

1. Corridor smoke detection is not required where sleeping rooms are provided with smoke detectors that comply with this Code. Such detectors shall provide a visual display on the corridor side of each sleeping room and an audible and visual alarm at the care provider's station attending each unit.
2. Corridor smoke detection is not required where sleeping room doors are equipped with automatic door-closing devices with integral smoke detectors on the unit sides installed in accordance with their listing, provided that the integral detectors perform the required alerting function.

4.7.10 Secured yards.
Grounds are permitted to be fenced and gates therein are permitted to be equipped with locks, provided that safe dispersal areas having 2.8 m$^2$ (30 net square feet) for bed and stretcher care recipients and 0.56 m$^2$ (6 net square feet) for ambulatory care recipients and other occupants are located between the building and the fence. Such provided safe dispersal areas shall be located not less than 15 240 mm (50 feet) from the building they serve.
4.7.11 Electrical systems.
In Group I-2 occupancies, the essential electrical system for electrical components, equipment and systems shall be designed and constructed in accordance with the provisions of Part 28 and the Ghana Fire Code.

4.8 GROUP I-3

4.8.1 General.
Occupancies in Group I-3 shall comply with the provisions of Clauses 4.8.1 through 4.8.11 and other applicable provisions of Clause 3.8.5.

4.8.2 Other occupancies.
Buildings or portions of buildings in Group I-3 occupancies where security operations necessitate the locking of required means of escape shall be permitted to be classified as a different occupancy. Occupancies classified as other than Group I-3 shall meet the applicable requirements of this Code for that occupancy where provisions are made for the release of occupants at all times.

Means of escape from detention and correctional occupancies that traverse other use areas shall, as a minimum, conform to requirements for detention and correctional occupancies.

Exception: It is permissible to exit through a horizontal exit into other contiguous occupancies that do not conform to detention and correctional occupancy escape provisions but that do comply with requirements set forth in the appropriate occupancy, as long as the occupancy is not a Group H use.

4.8.3 Means of escape.
Except as modified or as provided for in this clause, the means of escape provisions of Part 11 shall apply.

4.8.3.1 Door width.
Doors to resident sleeping units shall have a clear width of not less than 711 mm (28 inches).

4.8.3.2 Sliding doors.
Where doors in a means of escape are of the horizontal-sliding type, the force to slide the door to its fully open position shall be not greater than 220 N (50 pounds) with a perpendicular force against the door of 220 N (50 pounds).

4.8.3.3 Guard tower doors.
A hatch or trap door not less than $610 \text{ m}^2$ (16 square feet) in area through the floor and having dimensions of not less than 610 mm (2 feet) in any direction shall be permitted to be used as a portion of the means of escape from guard towers.

4.8.3.4 Spiral stairways.
Spiral stairways that conform to the requirements of this Code are permitted for access to and between staff locations.

4.8.3.5 Ships ladders.
Ships ladders shall be permitted for escape from control rooms or elevated facility observation rooms in accordance with this Code.

4.8.3.6 Exit discharge.
Exits are permitted to discharge into a fenced or walled courtyard. Enclosed yards or courts shall be of a size to accommodate all occupants, be located not less than 15 240 mm (50 feet) from the building and have an area of not less than $1.4 \text{ m}^2$ (15 square feet) per person.

4.8.3.7 Sallyports.
A sallyport shall be permitted in a means of escape where there are provisions for continuous and unobstructed passage through the sallyport during an emergency escape condition.

4.8.3.8 Interior exit stairway and ramp construction.
One interior exit stairway or ramp in each building shall be permitted to have glazing installed in doors and interior walls at each landing level providing access to the interior exit stairway or ramp, provided that the following conditions are met:

1. The interior exit stairway or ramp shall not serve more than four floor levels.

2. Exit doors shall be not less than $\frac{3}{4}$ -hour fire door assemblies complying with this Code.
3. The total area of glazing at each floor level shall not exceed 3.2 m² (5,000 square inches) and individual panels of glazing shall not exceed 0.84 m² (1,296 square inches).

4. The glazing shall be protected on both sides by an automatic sprinkler system. The sprinkler system shall be designed to wet completely the entire surface of any glazing affected by fire when actuated.

5. The glazing shall be in a gasketed frame and installed in such a manner that the framing system will deflect without breaking (loading) the glass before the sprinkler system operates.

6. Obstructions, such as curtain rods, drapery traverse rods, curtains, drapes or similar materials shall not be installed between the automatic sprinklers and the glazing.

4.8.4 Locks.

Escape doors are permitted to be locked in accordance with the applicable use condition. Doors from a refuge area to the outside are permitted to be locked with a key in lieu of locking methods described in Clause 4.8.4.1. The keys to unlock the exterior doors shall be available at all times and the locks shall be operable from both sides of the door.

4.8.4.1 Remote release.

Remote release of locks on doors in a means of escape shall be provided with reliable means of operation, remote from the resident living areas, to release locks on all required doors. In Occupancy Condition 3 or 4, the arrangement, accessibility and security of the release mechanisms required for escape shall be such that with the minimum available staff at any time, the lock mechanisms are capable of being released within 2 minutes.

Exception: Provisions for remote locking and unlocking of occupied rooms in Occupancy Condition 4 are not required provided that not more than 10 locks are necessary to be unlocked in order to move occupants from one smoke compartment to a refuge area within 3 minutes. The opening of necessary locks shall be accomplished with not more than two separate keys.

4.8.4.2 Power-operated doors and locks.

Power-operated sliding doors or power-operated locks for swinging doors shall be operable by a manual release mechanism at the door. Emergency power shall be provided for the doors and locks in accordance with this Code.

Exceptions:

1. Emergency power is not required in facilities with 10 or fewer locks complying with the exception to Clause 4.8.4.1.

2. Emergency power is not required where remote mechanical operating releases are provided.

4.8.4.3 Redundant operation.

Remote release, mechanically operated sliding doors or remote release, mechanically operated locks shall be provided with a mechanically operated release mechanism at each door, or shall be provided with a redundant remote release control.

4.8.4.4 Relock capability.

Doors remotely unlocked under emergency conditions shall not automatically relock when closed unless specific action is taken at the remote location to enable doors to relock.

4.8.5 Protection of vertical openings.

Any vertical opening shall be protected by a shaft enclosure in accordance with Clause 8.13 or shall be in accordance with Clause 4.8.5.1.

4.8.5.1 Floor openings.

Openings in floors within a housing unit are permitted without a shaft enclosure, provided that all of the following conditions are met:

1. The entire normally occupied areas so interconnected are open and unobstructed so as to enable observation of the areas by supervisory personnel.

2. Means of escape capacity is sufficient for all occupants from all interconnected cell tiers and areas.
3. The height difference between the floor levels of the highest and lowest cell tiers shall not exceed 23 feet (7010 mm).

4. Escape from any portion of the cell tier to an exit or exit access door shall not require travel on more than one additional floor level within the housing unit.

4.8.5.2 Shaft openings in communicating floor levels.

Where a floor opening is permitted between communicating floor levels of a housing unit in accordance with Clause 4.8.5.1, plumbing chases serving vertically staked individual cells contained within the housing unit shall be permitted without a shaft enclosure.

4.8.6 Smoke barrier.

Occupancies in Group I-3 shall have smoke barriers complying with Clauses 4.8.6 and 8.9 to divide every storey occupied by residents for sleeping, or any other storey having an occupant load of 50 or more persons, into not fewer than two smoke compartments.

Exception: Spaces having a direct exit to one of the following, provided that the locking arrangement of the doors involved complies with the requirements for doors at the smoke barrier for the use condition involved:

1. A public way.
2. A building separated from the resident housing area by a 2-hour fire-resistance-rated assembly or 15 240 mm (50 feet) of open space.
3. A secured yard or court having a holding space 15 240 mm (50 feet) from the housing area that provides 0.56 m$^2$ (6 square feet) or more of refuge area per occupant, including residents, staff and visitors.

4.8.6.1 Smoke compartments.

The number of residents in any smoke compartment shall not be more than 200. The distance of travel to a door in a smoke barrier from any room door required as exit access shall be not greater than 45 720 mm (150 feet). The distance of travel to a door in a smoke barrier from any point in a room shall be not greater than 200 feet (60 960 mm).

4.8.6.2 Refuge area.

Not less than 0.56 m$^2$ (6 net square feet) per occupant shall be provided on each side of each smoke barrier for the total number of occupants in adjoining smoke compartments. This space shall be readily available wherever the occupants are moved across the smoke barrier in a fire emergency.

4.8.6.3 Independent escape.

A means of escape shall be provided from each smoke compartment created by smoke barriers without having to return through the smoke compartment from which means of escape originates.

4.8.7 Security glazing.

In occupancies in Group I-3, windows and doors in 1-hour fire barriers constructed in accordance with Clause 8.7 fire partitions constructed in accordance with Clause 8.8 and smoke barriers constructed in accordance with Clause 8.9 shall be permitted to have security glazing installed provided that the following conditions are met.

1. Individual panels of glazing shall not exceed 0.84 m$^2$ (1,296 square inches).
2. The glazing shall be protected on both sides by an automatic sprinkler system. The sprinkler system shall be designed to, when actuated, wet completely the entire surface of any glazing affected by fire.
3. The glazing shall be in a gasketed frame and installed in such a manner that the framing system will deflect without breaking (loading) the glass before the sprinkler system operates.
4. Obstructions, such as curtain rods, drapery traverse rods, curtains, drapes or similar materials shall not be installed between the automatic sprinklers and the glazing.
4.8.8 Subdivision of resident housing areas.
Sleeping areas and any contiguous day room, group activity space or other common spaces where residents are housed shall be separated from other spaces in accordance with Clauses 4.8.8.1 through 4.8.8.4.

4.8.8.1 Occupancy Conditions 3 and 4.
Each sleeping area in Occupancy Conditions 3 and 4 shall be separated from the adjacent common spaces by a smoke-tight partition where the distance of travel from the sleeping area through the common space to the corridor exceeds 15 240 mm (50 feet).

4.8.8.2 Occupancy Condition 5.
Each sleeping area in Occupancy Condition 5 shall be separated from adjacent sleeping areas, corridors and common spaces by a smoke-tight partition. Additionally, common spaces shall be separated from the corridor by a smoke-tight partition.

4.8.8.3 Openings in room face.
The aggregate area of openings in a solid sleeping room face in Occupancy Conditions 2, 3, 4 and 5 shall not exceed 0.77 m² (120 square inches). The aggregate area shall include all openings including door undercuts, food passes and grilles. Openings shall be not more than 914 mm (36 inches) above the floor. In Occupancy Condition 5, the openings shall be closeable from the room side.

4.8.8.4 Smoke-tight doors.
Doors in openings in partitions required to be smoke tight by Clause 4.8.8 shall be substantial doors, of construction that will resist the passage of smoke. Latches and door closures are not required on cell doors.

4.8.9 Windowless buildings.
For the purposes of this clause, a windowless building or portion of a building is one with nonopenable windows, windows not readily breakable or without windows. Windowless buildings shall be provided with an engineered smoke control system to provide a tenable environment for exiting from the smoke compartment in the area of fire origin in accordance with Clause 10.9 for each windowless smoke compartment.

4.8.10 Fire alarm system.
A fire alarm system shall be provided in accordance with Clause 10.7.2.6.3.

4.8.11 Automatic sprinkler system.
Group I-3 occupancies shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.6.

4.9 MOTION PICTURE PROJECTION ROOMS

4.9.1 General.
The provisions of Clauses 4.9.1 through 4.9.5 shall apply to rooms in which ribbon-type cellulose acetate or other safety film is utilized in conjunction with electric arc, xenon or other light-source projection equipment that develops hazardous gases, dust or radiation. Where cellulose nitrate film is utilized or stored, such rooms shall comply with the Ghana Fire Code.

4.9.1.1 Projection room required.
Every motion picture machine projecting film as mentioned within the scope of this clause shall be enclosed in a projection room. Appurtenant electrical equipment, such as rheostats, transformers and generators, shall be within the projection room or in an adjacent room of equivalent construction.

4.9.2 Construction of projection rooms.
Every projection room shall be of permanent construction consistent with the construction requirements for the type of building in which the projection room is located. Openings are not required to be protected. The room shall have a floor area of not less than 80 square feet (7.44 m²) for a single machine and not less than 3.7 m² (40 square feet) for each additional machine. Each motion picture projector, floodlight, spotlight or similar piece of equipment shall have a clear working space of not less than 762 mm by 762 mm (30 inches by 30 inches) on each side and at the rear thereof, but only one such space shall be required between two adjacent projectors. The projection room and the rooms appurtenant thereto shall have a ceiling height of not less than 2286 mm (7 feet 6 inches). The aggregate of openings for projection equipment shall not exceed 25 percent of the area of the wall between the projection room and the auditorium. Openings shall be provided with
glass or other approved material, so as to close completely the opening.

4.9.3 Projection room and equipment ventilation.
Ventilation shall be provided in accordance with this Code.

4.9.3.1 Supply air.
Each projection room shall be provided with adequate air supply inlets so arranged as to provide well-distributed air throughout the room. Air inlet ducts shall provide an amount of air equivalent to the amount of air being exhausted by projection equipment. Air is permitted to be taken from the outside; from adjacent spaces within the building, provided that the volume and infiltration rate are sufficient; or from the building air-conditioning system, provided that it is so arranged as to provide sufficient air when other systems are not in operation.

4.9.3.2 Exhaust air.
Projection rooms are permitted to be exhausted through the lamp exhaust system. The lamp exhaust system shall be positively interconnected with the lamp so that the lamp will not operate unless there is the required airflow. Exhaust air ducts shall terminate at the exterior of the building in such a location that the exhaust air cannot be readily recirculated into any air supply system. The projection room ventilation system is permitted to also serve appurtenant rooms, such as the generator and rewind rooms.

4.9.3.3 Projection machines.
Each projection machine shall be provided with an exhaust duct that will draw air from each lamp and exhaust it directly to the outside of the building. The lamp exhaust is permitted to serve to exhaust air from the projection room to provide room air circulation. Such ducts shall be of rigid materials, except for a flexible connector approved for the purpose. The projection lamp or projection room exhaust system, or both, is permitted to be combined but shall not be interconnected with any other exhaust or return system, or both, within the building.

4.9.4 Lighting control.
Provisions shall be made for control of the auditorium lighting and the means of escape lighting systems of theaters from inside the projection room and from not less than one other convenient point in the building.

4.9.5 Miscellaneous equipment.
Each projection room shall be provided with rewind and film storage facilities.

4.10 STAGES, PLATFORMS AND TECHNICAL PRODUCTION AREAS

4.10.1 Applicability.
The provisions of Clauses 4.10.1 through 4.10.7 shall apply to all parts of buildings and structures that contain stages or platforms and similar appurtenances as herein defined.

4.10.2 Stages.
Stage construction shall comply with Clauses 4.10.2.1 through 4.10.2.7.

4.10.2.1 Stage construction.
Stages shall be constructed of materials as required for floors of the type of construction of the building. Stages need not be constructed of the same materials as required for the type of construction provided that the construction complies with one of the following:

1. Stages of Type IB or III construction with a nominal 51 mm (2-inch) wood deck, provided that the stage is separated from other areas in accordance with Clause 4.10.2.4.

2. In buildings of Type IA, IIA and IVA construction, a fire-resistance-rated floor is not required, provided that the space below the stage is equipped with an automatic sprinkler system or fire-extinguishing system in accordance with Clause 10.3 or 10.4.

3. In all types of construction, the finished floor shall be constructed of wood or approved noncombustible materials. Openings through
4.10.2.1 Stage height and area.

Stage areas shall be measured to include the entire performance area and adjacent backstage and support areas not separated from the performance area by fire-resistance-rated construction. Stage height shall be measured from the lowest point on the stage floor to the highest point of the roof or floor deck above the stage.

4.10.2.2 Technical production areas: galleries, gridirons and catwalks.

Beams designed only for the attachment of portable or fixed theater equipment, gridirons, galleries and catwalks shall be constructed of approved materials consistent with the requirements for the type of construction of the building; and a fire-resistance rating shall not be required. These areas shall not be considered to be floors, stories, mezzanines or levels in applying this Code.

Exception: Floors of fly galleries and catwalks shall be constructed of any approved material.

4.10.2.3 Exterior stage doors.

Where protection of openings is required, exterior exit doors shall be protected with fire door assemblies that comply with Clause 8.16. Exterior openings that are located on the stage for means of escape or loading and unloading purposes, and that are likely to be open during occupancy of the theater, shall be constructed with vestibules to prevent air drafts into the auditorium.

4.10.2.4 Proscenium wall.

Where the stage height is greater than 15 240 mm (50 feet), all portions of the stage shall be completely separated from the seating area by a proscenium wall with not less than a 2-hour fire-resistance rating extending continuously from the foundation to the roof.

4.10.2.5 Proscenium curtain.

Where a proscenium wall is required to have a fire-resistance rating, the stage opening shall be provided with a fire curtain complying with the Ghana Fire Code. Horizontal sliding doors shall comply with Clause 8.16 and have a fire protection rating of not less than 1 hour, or an approved water curtain complying with Clause 10.3.3.1.1. Facilities not utilizing the provisions of smoke-protected assembly seating in accordance with Clause 11.29.6.2, a smoke control system complying with Clause 10.9 or natural ventilation designed to maintain the smoke level not less than 1829 mm (6 feet) above the floor of the means of escape shall be required.

4.10.2.6 Scenery.

Combustible materials used in sets and scenery shall meet the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of ASTM E84, in accordance with Clause 9.6 and the Ghana Fire Code. Foam plastics and materials containing foam plastics shall comply with Clause 27.3 and the Ghana Fire Code.

4.10.2.7 Stage ventilation.

Emergency ventilation shall be provided for stages larger than 93 m² (1,000 square feet) in floor area, or with a stage height greater than 15 240 mm (50 feet). Such ventilation shall comply with Clause 4.10.2.7.1 or 4.10.2.7.2.

4.10.2.7.1 Roof vents.

Two or more vents constructed to open automatically by approved heat-activated devices and with an aggregate clear opening area of not less than 5 percent of the area of the stage shall be located near the center and above the highest part of the stage area. Supplemental means shall be provided for manual operation of the ventilator. Curbs shall be provided as required for skylights in Clause 27.10.2. Vents shall be labeled.

4.10.2.7.2 Smoke control.

Smoke control in accordance with Clause 10.9 shall be provided to maintain the smoke layer interface not less than 1829 mm (6 feet) above the highest level of the assembly seating or above the top of the proscenium opening where a proscenium wall is provided in compliance with this Code.
4.10.3 Platform construction.

Permanent platforms shall be constructed of materials as required for the type of construction of the building in which the permanent platform is located. Permanent platforms are permitted to be constructed of fire-retardant-treated wood for Types I and III construction where the platforms are not more than 762 mm (30 inches) above the main floor, and not more than one-third of the room floor area and not more than 279 m² (3,000 square feet) in area. Where the space beneath the permanent platform is used for storage or any purpose other than equipment, wiring or plumbing, the floor assembly shall be not less than 1-hour fire-resistance-rated construction. Where the space beneath the permanent platform is used only for equipment, wiring or plumbing, the underside of the permanent platform need not be protected.

4.10.3.1 Temporary platforms.

Platforms installed for a period of not more than 30 days are permitted to be constructed of any materials permitted by this Code. The space between the floor and the platform above shall only be used for plumbing and electrical wiring to platform equipment.

4.10.4 Dressing and appurtenant rooms.

Dressing and appurtenant rooms shall comply with Clauses 4.10.4.1 and 4.10.4.2.

4.10.4.1 Separation from stage.

The stage shall be separated from dressing rooms, scene docks, property rooms, workshops, storerooms and compartments appurtenant to the stage and other parts of the building by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. The fire-resistance rating shall be not less than 2 hours for stage heights greater than 15 240 mm (50 feet) and not less than 1 hour for stage heights of 15 240 mm (50 feet) or less.

4.10.4.2 Separation from each other.

Dressing rooms, scene docks, property rooms, workshops, storerooms and compartments appurtenant to the stage shall be separated from each other by not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.10.5 Means of escape.

Except as modified or as provided for in this clause, the provisions of Part 11 shall apply.

4.10.5.1 Arrangement.

Where two or more exits or exit access doorways from the stage are required in accordance with Clause 11.6.2, not fewer than one exit or exit access doorway shall be provided on each side of a stage.

4.10.5.2 Stairway and ramp enclosure.

Exit access stairways and ramps serving a stage or platform are not required to be enclosed. Exit access stairways and ramps serving technical production areas are not required to be enclosed.

4.10.5.3 Technical production areas.

Technical production areas shall be provided with means of escape and means of escape in accordance with Clauses 4.10.5.3.1 through 4.10.5.3.5.

4.10.5.3.1 Number of means of escape.

At least one means of escape shall be provided from technical production areas.

4.10.5.3.2 Exit access travel distance.

The exit access travel distance shall be not greater than 91 440 mm (300 feet) for buildings without a sprinkler system and 122 mm (400 feet) for buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

4.10.5.3.3 Two means of escape.

Where two means of escape are required, the common path of travel shall be not greater than 30 480 mm (100 feet).

Exception: A means of escape to a roof in place of a second means of escape is permitted.

4.10.5.3.4 Path of escape travel.

The following exit access components are permitted where serving technical production areas:

1. Stairways.
2. Ramps.
3. Spiral stairways.
5. Alternating tread devices.

6. Permanent ladders.

4.10.5.3.5 Width.
The path of escape travel within and from technical support areas shall be not less than 559 mm (22 inches).

4.10.6 Automatic sprinkler system.

Stages shall be equipped with an automatic sprinkler system in accordance with Clause 10.3.3.1.1. Sprinklers shall be installed under the roof and gridiron and under all catwalks and galleries over the stage. Sprinklers shall be installed in dressing rooms, performer lounges, shops and storerooms accessory to such stages.

Exceptions:

1. Sprinklers are not required under stage areas less than 1219 mm (4 feet) in clear height that are utilized exclusively for storage of tables and chairs, provided that the concealed space is separated from the adjacent spaces by Type X gypsum board not less than 15.9 mm (5/8 inch) in thickness.

2. Sprinklers are not required for stages 93 m² (1,000 square feet) or less in area and 15 240 mm (50 feet) or less in height where curtains, scenery or other combustible hangings are not retractable vertically. Combustible hangings shall be limited to a single main curtain, borders, legs and a single backdrop.

3. Sprinklers are not required within portable orchestra enclosures on stages.

4.11 SPECIAL AMUSEMENT BUILDINGS

4.11.1 General.

Special amusement buildings having an occupant load of 50 or more shall comply with the requirements for the appropriate Group A occupancy and Clauses 4.11.1 through 4.11.7. Special amusement buildings having an occupant load of less than 50 shall comply with the requirements for a Group B occupancy and Clauses 4.11.1 through 4.11.7.

Exception: Special amusement buildings or portions thereof that are without walls or a roof and constructed to prevent the accumulation of smoke need not comply with this clause.

For flammable decorative materials, see the Ghana Fire Code.

4.11.2 Automatic fire detection.

Special amusement buildings shall be equipped with an automatic fire detection system in accordance with this Code.

4.11.3 Automatic sprinkler system.

Special amusement buildings shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1. Where the special amusement building is temporary, the sprinkler water supply shall be of an approved temporary means.

Exception: Automatic sprinklers are not required where the total floor area of a temporary special amusement building is less than 93 m² (1,000 square feet) and the exit access travel distance from any point to an exit is less than 15 240 mm (50 feet).

4.11.4 Alarm.

Actuation of a single smoke detector, the automatic sprinkler system or other automatic fire detection device shall immediately sound an alarm at the building at a constantly attended location from which emergency action can be initiated including the capability of manual initiation of requirements in Clause 10.7.2.11.

4.11.5 Emergency voice/alarm communications system.

An emergency voice/alarm communications system shall be provided in accordance with Clauses 10.7.2.11 and 10.7.5.2.2 is permitted to serve as a public address system and shall...
be audible throughout the entire special amusement building.

### 4.11.6 Exit marking.

Exit signs shall be installed at the required exit or exit access doorways of amusement buildings in accordance with this clause and Clause 11.13. Approved directional exit markings shall be provided. Where mirrors, mazes or other designs are utilized that disguise the path of escape travel such that they are not apparent, approved and listed low-level exit signs that comply with Clause 11.13.5, and directional path markings listed in accordance with this Code shall be provided and located not more than 203 mm (8 inches) above the walking surface and on or near the path of escape travel. Such markings shall become visible in an emergency. The directional exit marking shall be activated by the automatic fire detection system and the automatic sprinkler system in accordance with Clause 10.7.2.11.

#### 4.11.6.1 Photoluminescent exit signs.

Where photoluminescent exit signs are installed, activating light source and viewing distance shall be in accordance with the listing and markings of the signs.

### 4.11.7 Interior finish.

The interior finish shall be Class A in accordance with Clause 9.3.1.

### 4.12 AIRCRAFT-RELATED OCCUPANCIES

#### 4.12.1 General.

Aircraft-related occupancies shall comply with Clauses 4.12.1 through 4.12.6 and the Ghana Fire Code.

#### 4.12.2 Airport traffic control towers.

The provisions of Clauses 4.12.2.1 through 4.12.2.6 shall apply to airport traffic control towers occupied only for the following uses:

1. Airport traffic control cab.
2. Electrical and mechanical equipment rooms.
3. Airport terminal radar and electronics rooms.
4. Office spaces incidental to the tower operation.

5. Lounges for employees, including sanitary facilities.

### 4.12.2.1 Construction.

The construction of airport traffic control towers shall comply with the provisions of Clauses 4.12.2.1.1 through 4.12.2.1.3.

#### 4.12.2.1.1 Type of construction.

Airport traffic control towers shall be constructed to comply with the height limitations of Table 4.12.2.1.1.

#### TABLE 4.12.2.1.1

<table>
<thead>
<tr>
<th>TYPE OF CONSTRUCTION</th>
<th>HEIGHT</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Unlimited</td>
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</tr>
<tr>
<td>IB</td>
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<tr>
<td>IIA</td>
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</tr>
<tr>
<td>IIB</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>IIIA</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m².  
  a. Height to be measured from grade plane to cab floor.

#### 4.12.2.1.2 Structural integrity of interior exit stairways and elevator hoistway enclosures.

Enclosures for interior exit stairways and elevator hoistway enclosures shall comply with Clause 4.3.2.3 in airport traffic control towers where the control cab is located more than 22 860 mm (75 feet) above the lowest level of fire department vehicle access.

#### 4.12.2.1.3 Sprayed fire-resistant materials (SFRM).

The bond strength of the SFRM installed in airport traffic control towers shall be in accordance with Clause 4.3.2.4 where the control cab is located more than 22 860 mm (75 feet) above the lowest level of fire department vehicle access.

#### 4.12.2.2 Means of escape and evacuation.

The means of escape in airport traffic control towers shall comply with Clauses 4.12.2.2.1 through 4.12.2.2.3.
4.12.2.2.1 Stairways.
Stairways in airport traffic control towers shall be in accordance with Clause 11.11. Exit stairways shall be smokeproof enclosures complying with one of the alternatives provided in Clause 10.9.20.

Exception: Stairways in airport traffic control towers are not required to comply with Clause 11.11.12.

4.12.2.2 Exit access.
From observation levels, airport traffic control towers shall be permitted to have a single means of exit access for a distance of travel not greater than 30 480 mm (100 feet). Exit access stairways from the observation level need not be enclosed.

4.12.2.2.3 Number of exits.
Not less than one exit stairway shall be permitted for airport traffic control towers of any height provided that the occupant load per floor is not greater than 15 and the area per floor does not exceed 140 m$^2$ (1,500 square feet).

4.12.2.2.3.1 Interior finish.
Where an airport traffic control tower is provided with only one exit stairway, interior wall and ceiling finishes shall be either Class A or Class B.

4.12.2.2.3.2 Exit separation.
Where an airport traffic control tower is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 and two exits are required, the exit separation distance required by Clause 11.7 shall be not less than one-fourth of the length of the maximum overall dimension of the area served.

4.12.2.3 Emergency systems.
The detection, alarm and emergency systems of airport traffic control towers shall comply with Clauses 4.12.2.3.1 through 4.12.2.3.3.

4.12.2.3.1 Automatic smoke detection systems.
Airport traffic control towers shall be provided with an automatic smoke detection system installed in accordance with Clause 10.7.2.21.

4.12.2.3.2 Fire command center.
A fire command center shall be provided in airport traffic control towers where the control cab is located more than 22 860 mm (75 feet) above the lowest level of fire department vehicle access. The fire command center shall comply with Clause 10.11.

Exceptions:
1. The fire command center shall be located in the airport control tower or an adjacent contiguous building where building functions are interdependent.
2. The room shall be not less than 14 m$^2$ (150 square feet) in area with a minimum dimension of 3048 mm (10 feet).
3. The following features shall not be required in an airport traffic control tower fire command center.
   3.1. Emergency voice/alarm control unit.
   3.2. Public address system.
   3.3. Status indicators and controls for the air distributions centers.
   3.4. Generator supervision devices, manual start and transfer features.
   3.5. Elevator emergency or standby power switches where emergency or standby power is provided.

4.12.2.3.3 Smoke removal.
Smoke removal in airport traffic control towers shall be provided in accordance with Clause 4.3.4.7.

4.12.2.4 Automatic sprinkler system.
Where an occupied floor is located more than 10 668 mm (35 feet) above the lowest level of fire department vehicle access, airport traffic control towers shall be equipped with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.
4.12.2.4.1 Fire pump room.

Fire pumps shall be located in rooms that are separated from all other areas of the building by 2-hour fire barriers constructed in accordance with Clause 8.7 or 2-hour horizontal assemblies constructed in accordance with Clause 8.11, or both.

**Exception:** Separation is not required for fire pumps physically separated in accordance with the Ghana Fire Code.

4.12.2.5 Protection of elevator wiring and cables.

Wiring and cables serving elevators in airport traffic control towers shall be protected in accordance with this Code.

4.12.2.5.1 Elevators for occupant evacuation.

Where provided in addition to an exit stairway, occupant evacuation elevators shall be in accordance with this Code.

4.12.2.6 Accessibility.

Airport traffic control towers shall be accessible except as specified in this Code.

4.12.3 Aircraft hangars.

Aircraft hangars shall be in accordance with Clauses 4.12.3.1 through 4.12.3.6.

4.12.3.1 Exterior walls.

Exterior walls located less than 9144 mm (30 feet) from plot lines or a public way shall have a fire-resistance rating not less than 2 hours.

4.12.3.2 Basements.

Where hangars have basements, floors over basements shall be of Type IA construction and shall be made tight against seepage of water, oil or vapours. There shall not be openings or communication between basements and the hangar. Access to basements shall be from outside only.

4.12.3.3 Floor surface.

Floors shall be graded and drained to prevent water or fuel from remaining on the floor. Floor drains shall discharge through an oil separator to the sewer or to an outside vented sump.

**Exception:** Aircraft hangars with individual lease spaces not exceeding 186 m² (2,000 square feet) each in which servicing, repairing or washing is not conducted and fuel is not dispensed shall have floors that are graded toward the door, but shall not require a separator.

4.12.3.4 Heating equipment.

Heating equipment shall be placed in another room separated by 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. Entrance shall be from the outside or by means of a vestibule providing a two-doorway separation.

**Exceptions:**

1. Unit heaters and vented infrared radiant heating equipment suspended not less than 3048 mm (10 feet) above the upper surface of wings or engine enclosures of the highest aircraft that are permitted to be housed in the hangar need not be located in a separate room provided that they are mounted not less than 2438 mm (8 feet) above the floor in shops, offices and other clauses of the hangar communicating with storage or service areas.

2. Entrance to the separated room shall be permitted by a single interior door provided that the sources of ignition in the appliances are not less than 457 mm (18 inches) above the floor.

4.12.3.5 Finishing.

The process of “doping,” involving use of a volatile flammable solvent, or of painting, shall be carried on in a separate detached building equipped with automatic fire-extinguishing equipment in accordance with Clause 10.3.

4.12.3.6 Fire suppression.

Aircraft hangars shall be provided with a fire suppression system designed in accordance with the Ghana Fire Code, based on the classification for the hangar given in Table 4.12.3.6.
Exception: Where a fixed base operator has separate repair facilities on site, Group II hangars operated by a fixed base operator used for storage of transient aircraft only shall have a fire suppression system, but the system is exempt from foam requirements.

[F] TABLE 4.12.3.6
HANGAR FIRE SUPPRESSION REQUIREMENTS

<table>
<thead>
<tr>
<th>MAXIMUM SINGLE FIRE AREA (square feet)</th>
<th>TYPE OF CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IA</td>
</tr>
<tr>
<td>≥ 40,001</td>
<td>Group I</td>
</tr>
<tr>
<td>40,000</td>
<td>Group II</td>
</tr>
<tr>
<td>30,000</td>
<td>Group III</td>
</tr>
<tr>
<td>20,000</td>
<td>Group III</td>
</tr>
<tr>
<td>15,000</td>
<td>Group III</td>
</tr>
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<td>Group III</td>
</tr>
<tr>
<td>8,000</td>
<td>Group III</td>
</tr>
<tr>
<td>5,000</td>
<td>Group III</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m².

a. Aircraft hangars with a door height greater than 28 feet shall be provided with fire suppression for a Group I hangar regardless of maximum fire area.

b. Groups shall be as classified in accordance with the Ghana Fire Code.

c. Membrane structures complying with Clause 32.2 shall be classified as a Group IV hangar.

4.12.3.6.1 Hazardous operations.

Any Group III aircraft hangar according to Table 4.12.3.6 that contains hazardous operations including, but not limited to, the following shall be provided with a Group I or II fire suppression system in accordance with the Ghana Fire Code as applicable:

1. Doping.

2. Hot work including, but not limited to, welding, torch cutting and torch soldering.

3. Fuel transfer.

4. Fuel tank repair or maintenance not including defueled tanks in accordance with the Ghana Fire Code, inerted tanks or tanks that have never been fueled.

5. Spray finishing operations.

6. Total fuel capacity of all aircraft within the unsprinklered single fire area in excess of 6057 L (1,600 gallons).

7. Total fuel capacity of all aircraft within the maximum single fire area in excess of 28390 L (7,500 gallons) for a hangar with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

4.12.3.6.2 Separation of maximum single fire areas.

Maximum single fire areas established in accordance with hangar classification and construction type in Table 4.12.3.6 shall be separated by 2-hour fire walls constructed in accordance with Clause 8.6. In determining the maximum single fire area as set forth in Table 4.12.3.6, ancillary uses that are separated from aircraft servicing areas by a fire barrier of not
less than 1 hour, constructed in accordance with Clause 8.7, shall not be included in the area.

4.12.4 Residential aircraft hangars.
Residential aircraft hangars shall comply with Clauses 4.12.4.1 through 4.12.4.5.

4.12.4.1 Fire separation.
A hangar shall not be attached to a dwelling unless separated by a fire barrier having a fire-resistance rating of not less than 1 hour. Such separation shall be continuous from the foundation to the underside of the roof and unperforated except for doors leading to the dwelling unit. Doors into the dwelling unit shall be equipped with self-closing devices and conform to the requirements of Clause 8.16 with a noncombustible raised sill not less than 102 mm (4 inches) in height. Openings from a hangar directly into a room used for sleeping purposes shall not be permitted.

4.12.4.2 Escape.
A hangar shall provide two means of escape. One of the doors into the dwelling shall be considered as meeting only one of the two means of escape.

4.12.4.3 Smoke alarms.
Smoke alarms shall be provided within the hangar in accordance with Clause 10.7.2.21.

4.12.4.4 Independent systems.
Electrical, mechanical and plumbing drain, waste and vent (DWV) systems installed within the hangar shall be independent of the systems installed within the dwelling. Building sewer lines shall be permitted to be connected outside the structures.

Exception: Smoke detector wiring and feed for electrical subpanels in the hangar.

4.12.4.5 Height and area limits.
Residential aircraft hangars shall be not greater than 186 m² (2,000 square feet) in area and 6096 mm (20 feet) in building height.

4.12.5 Aircraft paint hangars.
Aircraft painting operations shall be conducted in an aircraft paint hangar that complies with the provisions of Clauses 4.12.5.1 through 4.12.5.8. Buildings and structures, or parts thereof, used for the application of flammable finishes shall comply with the applicable provisions of Clause 4.16.

4.12.5.1 Occupancy classification.
Aircraft paint hangars shall be classified in accordance with the provisions of Clause 3.7.1. Aircraft paint hangars shall comply with the applicable requirements of this Code and the Ghana Fire Code for such occupancy.

4.12.5.2 Construction.
Aircraft paint hangars shall be of Type I construction.

4.12.5.3 Spray equipment cleaning operations.
Spray equipment cleaning operations shall be conducted in a liquid use, dispensing and mixing room.

4.12.5.4 Operations.
Only those flammable liquids necessary for painting operations shall be permitted in quantities less than the maximum allowable quantities per control area in Table 3.7.1(1). Spray equipment cleaning operations exceeding the maximum allowable quantities per control area in Table 3.7.1(1) shall be conducted in a liquid use, dispensing and mixing room.

4.12.5.5 Storage.
Storage of flammable or combustible liquids exceeding the maximum allowable quantities per control area in Table 3.7.1(1) shall be in a liquid storage room.

4.12.5.6 Fire suppression.
Aircraft paint hangars shall be provided with fire suppression as required by the Ghana Fire Code.

4.12.5.7 Ventilation.
Aircraft paint hangars shall be provided with ventilation as required in this Code.

4.12.5.8 Electrical.
Electrical equipment and devices within the aircraft paint hangar shall comply with Ghana Wiring Code.
4.12.5.8.1 Class I, Division I hazardous locations.
The area within 3048 mm (10 feet) horizontally from aircraft surfaces and from the floor to 3048 mm (10 feet) above the aircraft surface shall be classified as a Class I, Division I location.

4.12.5.8.2 Class I, Division 2 hazardous locations.
The area horizontally from aircraft surfaces between 3048 mm (10 feet) and 9144 mm (30 feet) and from the floor to 9144 mm (30 feet) above the aircraft surface shall be classified as a Class I, Division 2 location.

4.12.6 Heliports and helistops.
Heliports and helistops shall be permitted to be erected on buildings or other locations where they are constructed in accordance with Clauses 4.12.6.1 through 4.12.6.5.

4.12.6.1 Size.
The landing area for helicopters less than 1588 kg (3,500 pounds) shall be not less than 6096 mm (20 feet) in length and width. The landing area shall be surrounded on all sides by a clear area having an average width at roof level of 4572 mm (15 feet), and all widths shall be not less than 1524 mm (5 feet).

4.12.6.2 Design.
Helicopter landing areas and the supports thereof on the roof of a building shall be noncombustible construction. Landing areas shall be designed to confine any flammable liquid spillage to the landing area itself and provisions shall be made to drain such spillage away from any exit or stairway serving the helicopter landing area or from a structure housing such exit or stairway.

4.12.6.3 Means of escape.
The means of escape from heliports and helistops shall comply with the provisions of Part 11. Landing areas located on buildings or structures shall have two or more means of escape. For landing areas less than 18 288 mm² (60 feet) in length or less than 186 m² (2,000 square feet) in area, the second means of escape is permitted to be a fire escape, alternating tread device or ladder leading to the floor below.

4.12.6.4 Rooftop heliports and helistops.
Rooftop heliports and helistops shall comply with NFPA 418.

4.12.6.5 Fire hydrant system.
In buildings equipped with a Fire hydrant system, the Fire hydrant shall extend to the roof level in accordance with Clause 10.5.3.6.

4.13 COMBUSTIBLE STORAGE

4.13.1 General.
High-piled stock or rack storage in any occupancy group shall comply with the Ghana Fire Code.

4.13.2 Attic, under-floor and concealed spaces.
Attic, under-floor and concealed spaces used for storage of combustible materials shall be protected on the storage side as required for 1-hour fire-resistance-rated construction. Openings shall be protected by assemblies that are self-closing and are of noncombustible construction or solid wood core not less than 45 mm (1 3/4 inch) in thickness.

Exception: Neither fire-resistance-rated construction nor opening protectives are required in any of the following locations:

1. Areas protected by approved automatic sprinkler systems.
2. Group R-3 and U occupancies.

4.14 HAZARDOUS MATERIALS

The provisions of Clauses 4.14.1 through 4.14.6 shall apply to buildings and structures occupied for the manufacturing, processing, dispensing, use or storage of hazardous materials.

4.14.1.1 Other provisions.
Buildings and structures with an occupancy in Group H shall comply with this clause and the applicable provisions of Clause 4.15 and the Ghana Fire Code.
The safe design of hazardous material occupancies is material dependent. Individual material requirements are found in Clauses 3.7, 4.15 and the Ghana Fire Code.

4.14.1.2.1 Aerosol products.
Level 2 and 3 aerosol products shall be stored and displayed in accordance with the Ghana Fire Code. See Clause 3.11.2 and the Ghana Fire Code for occupancy group requirements.

4.14.1.3 Information required.
A report shall be submitted to the building official identifying the maximum expected quantities of hazardous materials to be stored, used in a closed system and used in an open system, and subdivided to separately address hazardous material classification categories based on Tables 3.7.1(1) and 3.7.1(2). The methods of protection from such hazards, including but not limited to control areas, fire protection systems and Group H occupancies shall be indicated in the report and on the construction documents. The opinion and report shall be prepared by a qualified person, firm or corporation approved by the building official and provided without charge to the enforcing agency.

For buildings and structures with an occupancy in Group H, separate floor plans shall be submitted identifying the locations of anticipated contents and processes so as to reflect the nature of each occupied portion of every building and structure.

4.14.2 Control areas.
Control areas shall comply with Clauses 4.14.2.1 through 4.14.2.5 and the Ghana Fire Code.

Exception: Higher education laboratories in accordance with Clause 4.28 and Part 38 of the Ghana Fire Code.

4.14.2.1 Construction requirements.
Control areas shall be separated from each other by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.14.2.2 Percentage of maximum allowable quantities.
The percentage of maximum allowable quantities of hazardous materials per control area permitted at each floor level within a building shall be in accordance with Table 4.14.2.2.

<table>
<thead>
<tr>
<th>STOREY</th>
<th>PERCENTAGE OF THE MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA a</th>
<th>NUMBER OF CONTROL AREAS PER STOREY</th>
<th>FIRE-RESISTANCE RATING FOR FIRE BARRIERS IN HOURS b</th>
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</thead>
<tbody>
<tr>
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<td>Higher than 9</td>
<td>Higher than 9</td>
<td>2</td>
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<tr>
<td></td>
<td>7–9</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>12.5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>12.5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>75</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>100</td>
<td>1</td>
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<tr>
<td>Below grade plane</td>
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<td>3</td>
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<td></td>
<td>2</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Lower than 2</td>
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<td>Not Allowed</td>
</tr>
</tbody>
</table>

NOTE:
4.14.2.3 Number.
The maximum number of control areas within a building shall be in accordance with Table 4.14.2.2.

4.14.2.4 Fire-resistance rating requirements.
The required fire-resistance rating for fire barriers shall be in accordance with Table 4.14.2.2. The floor assembly of the control area and the construction supporting the floor of the control area shall have a fire-resistance rating of not less than 2 hours.

**Exception:** The floor assembly of the control area and the construction supporting the floor of the control area are allowed to be 1-hour fire-resistance-rated in buildings of Types IA, IIA and III construction, provided that both of the following conditions exist:

1. The building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.
2. The building is three or fewer stories above grade plane.

4.14.2.5 Hazardous material in Group M display and storage areas and in Group S storage areas.
Hazardous materials located in Group M and Group S occupancies shall be in accordance with Clauses 4.14.2.5.1 through 4.14.2.5.3.

[F] TABLE 4.14.2.5(1)
MAXIMUM ALLOWABLE QUANTITY PER INDOOR AND OUTDOOR CONTROL AREA IN GROUP M AND S OCCUPANCIES NONFLAMMABLE SOLIDS AND NONFLAMMABLE AND NONCOMBUSTIBLE LIQUIDS
d, e, f

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>MAXIMUM ALLOWABLE</th>
</tr>
</thead>
</table>

a. Percentages shall be of the maximum allowable quantity per control area shown in Tables 3.7.1(1) and 3.7.1(2), with all increases allowed in the notes to those tables.
b. Separation shall include fire barriers and horizontal assemblies as necessary to provide separation from other portions of the building.
4.14.2.5.1 Nonflammable solids and nonflammable and noncombustible liquids.

The aggregate quantity of nonflammable solid and nonflammable or noncombustible liquid hazardous materials permitted within a single control area of a Group M display and storage area, a Group S storage area or an outdoor control area is permitted to exceed the maximum allowable quantities per control area specified in Tables 3.7.1(1) and 3.7.1(2) without classifying the building or use as a Group H occupancy, provided that the materials are displayed and stored in accordance with the Ghana Fire Code and quantities do not exceed the maximum allowable specified in Table 4.14.2.5(1).

4.14.2.5.2 Flammable and combustible liquids.

In Group M occupancy wholesale and retail sales uses, indoor storage of flammable and combustible liquids shall not exceed the maximum allowable quantities per control area as indicated in Table 4.14.2.5(2), provided that the materials are displayed and stored in accordance with the Ghana Fire Code.

4.14.2.5.3 Aerosol products.

The maximum quantity of aerosol products in Group M occupancy retail display areas, storage areas adjacent to retail display areas and retail storage areas shall be in accordance with the Ghana Fire Code.


Rooms, areas or spaces in which explosive, corrosive, combustible, flammable or highly toxic dusts, mists, fumes, vapours or gases are or have the potential to be emitted due to the processing, use, handling or storage of materials shall be mechanically ventilated where required by this Code and the Ghana Fire Code.
# EXPLOSION CONTROL REQUIREMENTS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CLASS</th>
<th>EXPLOSION CONTROL METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Barricade construction</td>
</tr>
<tr>
<td>HAZARD CATEGORY</td>
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<td></td>
</tr>
<tr>
<td>Combustible dusts c</td>
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</tr>
<tr>
<td>Cryogenic flammables</td>
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<td></td>
</tr>
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</tr>
<tr>
<td>Division 1.2</td>
<td>Required</td>
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</tr>
<tr>
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<td>Required</td>
</tr>
<tr>
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</tr>
<tr>
<td>Division 1.5</td>
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</tr>
<tr>
<td>Division 1.6</td>
<td>Required</td>
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</tr>
<tr>
<td>Flammable gas</td>
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<td></td>
</tr>
<tr>
<td>Gaseous</td>
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<td>Required</td>
</tr>
<tr>
<td>Liquefied</td>
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<td>Required</td>
</tr>
<tr>
<td>Flammable liquid</td>
<td>d</td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>Not Required</td>
<td>Required</td>
</tr>
<tr>
<td>IB</td>
<td>Not Required</td>
<td>Required</td>
</tr>
<tr>
<td>Organic peroxides</td>
<td>U</td>
<td>Required</td>
</tr>
<tr>
<td>I</td>
<td>Required</td>
<td>Not Permitted</td>
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<tr>
<td>Oxidizer liquids and solids</td>
<td>4</td>
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<td>Pyrophoric gas</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Not Required</td>
<td>Required</td>
</tr>
<tr>
<td>Unstable (reactive)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3 Detonable</td>
<td>Required</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>3 Nondetonable</td>
<td>Required</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>Water-reactive liquids and solids</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2 g</td>
<td>Not Required</td>
<td>Required</td>
</tr>
<tr>
<td>SPECIAL USES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylene generator rooms</td>
<td>—</td>
<td>Not Required</td>
</tr>
<tr>
<td>Grain processing</td>
<td>—</td>
<td>Not Required</td>
</tr>
<tr>
<td>Liquefied petroleum gas-distribution facilities</td>
<td>—</td>
<td>Not Required</td>
</tr>
<tr>
<td>Where explosion hazards exist</td>
<td>Detonation</td>
<td>Required</td>
</tr>
<tr>
<td>Deflagration</td>
<td>Not Required</td>
<td>Required</td>
</tr>
</tbody>
</table>

b. See the Ghana Fire Code.
c. As generated during manufacturing or processing.
d. Storage or use.
e. In open use or dispensing.
f. Rooms containing dispensing and use of hazardous materials where an explosive environment can occur because of the characteristics or nature of the hazardous materials or as a result of the dispensing or use process.
g. A method of explosion control shall be provided where Class 2 water-reactive materials can form potentially explosive mixtures.
h. Explosion venting is not required for Group H-5 fabrication areas complying with Clause 4.15.11.1 and the Ghana Fire Code.
4.14.5.2 Emergency or standby power.
Where required by the Ghana Fire Code or this Code, mechanical ventilation, treatment systems, temperature control, alarm, detection or other electrically operated systems shall be provided with emergency or standby power in accordance with Clause 28.13. For storage and use areas for highly toxic or toxic materials, see Clauses 6004.2.2.8 and 6004.3.4.2 of the Ghana Fire Code.

4.14.5.2.1 Exempt applications.
Emergency or standby power is not required for the mechanical ventilation systems provided for any of the following:

1. Storage of Class IB and IC flammable and combustible liquids in closed containers not exceeding 25 L (6.5 gallons) capacity.
2. Storage of Class 1 and 2 oxidizers.
4. Storage of asphyxiant, irritant and radioactive gases.

4.14.5.2.2 Fail-safe engineered systems.
Standby power for mechanical ventilation, treatment systems and temperature control systems shall not be required where an approved fail-safe engineered system is installed.

4.14.5.3 Spill control, drainage and containment.
Rooms, buildings or areas occupied for the storage of solid and liquid hazardous materials shall be provided with a means to control spillage and to contain or drain off spillage and fire protection water discharged in the storage area where required in the Ghana Fire Code. The methods of spill control shall be in accordance with the Ghana Fire Code.

4.14.6 Outdoor storage, dispensing and use.
The outdoor storage, dispensing and use of hazardous materials shall be in accordance with the Ghana Fire Code.

Where weather protection is provided for sheltering outdoor hazardous material storage or use areas, such areas shall be considered outdoor storage or use where the weather protection structure complies with Clauses 4.14.6.1.1 through 4.14.6.1.3.

4.14.6.1.1 Walls.
Walls shall not obstruct more than one side of the structure.

Exception: Walls shall be permitted to obstruct portions of multiple sides of the structure, provided that the obstructed area is not greater than 25 percent of the structure’s perimeter.

4.14.6.1.2 Separation distance.
The distance from the structure to buildings, plot lines, public ways or means of escape to a public way shall be not less than the distance required for an outside hazardous material storage or use area without weather protection.

4.14.6.1.3 Noncombustible construction.
The overhead structure shall be of approved noncombustible construction with a maximum area of 140 m² (1,500 square feet).

Exception: The maximum area is permitted to be increased as provided by Clause 6.9.

4.15 GROUPS H-1, H-2, H-3, H-4 AND H-5

4.15.1 General.
The provisions of Clauses 4.15.1 through 4.15.11 shall apply to the storage and use of hazardous materials in excess of the maximum allowable quantities per control area listed in this Code.

4.15.2 Compliance.
Buildings and structures with an occupancy in Group H shall comply with the applicable provisions of Clause 4.14 and the Ghana Fire Code.

4.15.3 Automatic fire detection systems.
Group H occupancies shall be provided with an automatic fire detection system in accordance with Clause 10.7.2.
4.15.4 Automatic sprinkler system.
Group H occupancies shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.5.

4.15.5 Emergency alarms.
Emergency alarms for the detection and notification of an emergency condition in Group H occupancies shall be provided as set forth herein.

4.15.5.1 Storage.
An approved manual emergency alarm system shall be provided in buildings, rooms or areas used for storage of hazardous materials. Emergency alarm-initiating devices shall be installed outside of each interior exit or exit access door of storage buildings, rooms or areas. Activation of an emergency alarm-initiating device shall sound a local alarm to alert occupants of an emergency situation involving hazardous materials.

4.15.5.2 Dispensing, use and handling.
Where hazardous materials having a hazard ranking of 3 or 4 in accordance with the Ghana Fire Code are transported through corridors, interior exit stairways or ramps, or exit passageways, there shall be an emergency telephone system, a local manual alarm station or an approved alarm-initiating device at not more than 45 720 mm (150-foot) intervals and at each exit and exit access doorway throughout the transport route. The signal shall be relayed to an approved central, proprietary or remote station service or constantly attended on-site location and shall initiate a local audible alarm.

4.15.5.3 Supervision.
Emergency alarm systems required by Clause 4.15.5.1 or 4.15.5.2 shall be electrically supervised and monitored by an approved central, proprietary or remote station service or shall initiate an audible and visual signal at a constantly attended on-site location.

4.15.5.4 Emergency alarm systems.
Emergency alarm systems required by Clause 4.15.5.1 or 4.15.5.2 shall be provided with emergency or standby power in accordance with Clause 28.13.2.

4.15.6 Fire separation distance.
Group H occupancies shall be located on property in accordance with the other provisions of this part. In Groups H-2 and H-3, not less than 25 percent of the perimeter wall of the occupancy shall be an exterior wall.

Exceptions:

1. Liquid use, dispensing and mixing rooms having a floor area of not more than 46.5 m$^2$ (500 square feet) need not be located on the outer perimeter of the building where they are in accordance with the Ghana Fire Code.

2. Liquid storage rooms having a floor area of not more than 93 m$^2$ (1,000 square feet) need not be located on the outer perimeter where they are in accordance with the Ghana Fire Code.

3. Spray paint booths that comply with the Ghana Fire Code need not be located on the outer perimeter.

4.15.6.1 Group H occupancy minimum fire separation distance.
Regardless of any other provisions, buildings containing Group H occupancies shall be set back to the minimum fire separation distance as set forth in Clauses 4.15.6.1.1 through 4.15.6.1.4. Distances shall be measured from the walls enclosing the occupancy to plot lines, including those on a public way. Distances to assumed plot lines established for the purpose of determining exterior wall and opening protection are not to be used to establish the minimum fire separation distance for buildings on sites where explosives are manufactured or used where separation is provided in accordance with the quantity distance tables specified for explosive materials in the Ghana Fire Code.

4.15.6.1.1 Group H-1.
Group H-1 occupancies shall be set back not less than 22 860 mm (75 feet) and not less than required by the Ghana Fire Code.

Exception: Fireworks manufacturing buildings separated in accordance with the Ghana Fire Code.
### 4.15.6.2 Group H-2.
Group H-2 occupancies shall be set back not less than 9144 mm (30 feet) where the area of the occupancy is greater than 93 m² (1,000 square feet) and it is not required to be located in a detached building.

### 4.15.6.3 Groups H-2 and H-3.
Group H-2 and H-3 occupancies shall be set back not less than 15 240 mm (50 feet) where a detached building is required (see Table 4.15.6.2).

### 4.15.6.4 Explosive materials.
Group H-2 and H-3 occupancies containing materials with explosive characteristics shall be separated as required by the Ghana Fire Code. Where separations are not specified, the distances required shall be determined by a technical report issued in accordance with Clause 4.14.1.3.

### 4.15.6.2 Detached buildings for Group H-1, H-2 or H-3 occupancy.
The storage or use of hazardous materials in excess of those amounts listed in Table 4.15.6.2 shall be in accordance with the applicable provisions of Clauses 4.15.7 and 4.15.8.

<table>
<thead>
<tr>
<th>Material</th>
<th>Class</th>
<th>Solids and Liquids (tons) a,b</th>
<th>Gases (cubic a,b feet)</th>
<th>Quantity</th>
<th>Division 1.4c</th>
<th>Division 1.5</th>
<th>Division 1.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosives</td>
<td>Division 1.1</td>
<td>Maximum Allowable Quantity</td>
<td>Maximum Allowable Quantity</td>
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<td>Maximum Allowable Quantity</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Division 1.3</td>
<td>Maximum Allowable Quantity</td>
<td>Maximum Allowable Quantity</td>
<td>Not Applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Division 1.4</td>
<td>Maximum Allowable Quantity</td>
<td>Maximum Allowable Quantity</td>
<td>Not Applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### TABLE 4.15.6.2 DETACHED BUILDING REQUIRED

<table>
<thead>
<tr>
<th>Material</th>
<th>Class</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxidizers</td>
<td>Class 4</td>
<td>Maximum Allowable Quantity</td>
</tr>
<tr>
<td>Unstable (reactives) detonable</td>
<td>Class 3 or 4</td>
<td>Maximum Allowable Quantity</td>
</tr>
<tr>
<td>Oxidizer, liquids and solids</td>
<td>Class 3</td>
<td>1,200</td>
</tr>
<tr>
<td>Detonable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic peroxides</td>
<td>Class I</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Class II</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Class III</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Water reactives</td>
<td>Class 3</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td>10,000</td>
</tr>
</tbody>
</table>

For SI: 1 ton = 906 kg, 1 cubic foot = 0.02832 m³, 1 pound = 0.454 kg.

a. For materials that are detonable, the distance to other buildings or plot lines shall be in accordance with Clause 4.15.6 of this Code or the Ghana Fire Code based on trinitrotoluene (TNT) equivalence of the material, whichever is greater.
b. Maximum Allowable Quantity means the maximum allowable quantity per control area set forth in Table 3.7.1(1).
c. Limited to Division 1.4 materials and articles, including packaged for shipment, that are not regulated as an explosive under Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) regulations or unpackaged articles used in process operations that do not propagate a detonation or deflagration between articles, provided that the net explosive weight of individual articles does not exceed 1 pound.

### 4.15.6.2.1 Wall and opening protection.
Where a detached building is required by Table 4.15.6.2, wall and opening protection based on fire separation distance is not required.

### 4.15.7 Special provisions for Group H-1 occupancies.
Group H-1 occupancies shall be in detached buildings not used for other purposes. Roofs shall be of lightweight construction with suitable
thermal insulation to prevent sensitive material from reaching its decomposition temperature. Group H-1 occupancies containing materials that are in themselves both physical and health hazards in quantities exceeding the maximum allowable quantities per control area in Table 3.7.1(2) shall comply with requirements for both Group H-1 and H-4 occupancies.

4.15.7.1 Floors in storage rooms.
Floors in storage areas for organic peroxides, pyrophoric materials and unstable (reactive) materials shall be of liquid-tight, noncombustible construction.

4.15.8 Special provisions for Group H-2 and H-3 occupancies.
Group H-2 and H-3 occupancies containing quantities of hazardous materials in excess of those set forth in Table 4.15.6.2 shall be in detached buildings used for manufacturing, processing, dispensing, use or storage of hazardous materials. Materials listed for Group H-1 occupancies in Clause 3.7.3 are permitted to be located within Group H-2 or H-3 detached buildings provided that the amount of materials per control area do not exceed the maximum allowed quantity specified in Table 3.7.1(1).

4.15.8.1 Multiple hazards.
Group H-2 or H-3 occupancies containing materials that are in themselves both physical and health hazards in quantities exceeding the maximum allowable quantities per control area in Table 3.7.1(2) shall comply with requirements for Group H-2, H-3 or H-4 occupancies as applicable.

4.15.8.2 Separation of incompatible materials.
Hazardous materials other than those listed in Table 4.15.6.2 shall be allowed in manufacturing, processing, dispensing, use or storage areas when separated from incompatible materials in accordance with the provisions of the Ghana Fire Code.

4.15.8.3 Water reactives.
Group H-2 and H-3 occupancies containing water-reactive materials shall be resistant to water penetration. Piping for conveying liquids shall not be over or through areas containing water reactives, unless isolated by approved liquid-tight construction.

Exception: Fire protection piping shall be permitted over or through areas containing water reactives without isolating it with liquid-tight construction.

4.15.8.4 Floors in storage rooms.
Floors in storage areas for organic peroxides, oxidizers, pyrophoric materials, unstable (reactive) materials and water-reactive solids and liquids shall be of liquid-tight, noncombustible construction.

4.15.8.5 Waterproof room.
Rooms or areas used for the storage of water-reactive solids and liquids shall be constructed in a manner that resists the penetration of water through the use of waterproof materials. Piping carrying water for other than approved automatic sprinkler systems shall not be within such rooms or areas.

4.15.9 Group H-2.
Occupancies in Group H-2 shall be constructed in accordance with Clauses 4.15.9.1 through 4.15.9.3 and the Ghana Fire Code.

4.15.9.1 Flammable and combustible liquids.
The storage, handling, processing and transporting of flammable and combustible liquids in Group H-2 and H-3 occupancies shall be in accordance with Clauses 4.15.9.1.1 through 4.15.9.1.9 and the Ghana Fire Code.

4.15.9.1.1 Mixed occupancies.
Where the storage tank area is located in a building of two or more occupancies and the quantity of liquid exceeds the maximum allowable quantity for one control area, the use shall be completely separated from adjacent occupancies in accordance with the requirements of Clause 6.11.4.

4.15.9.1.1 Height exception.
Where storage tanks are located within a building not more than one storey above grade plane, the height limitation of Clause 6.4 shall not apply for Group H.
4.15.9.1.2 Tank protection.

Storage tanks shall be noncombustible and protected from physical damage. Fire barriers or horizontal assemblies or both around the storage tanks shall be permitted as the method of protection from physical damage.

4.15.9.1.3 Tanks.

Storage tanks shall be approved tanks conforming to the requirements of the Ghana Fire Code.

4.15.9.1.4 Leakage containment.

A liquid-tight containment area compatible with the stored liquid shall be provided. The method of spill control, drainage control and secondary containment shall be in accordance with the Ghana Fire Code.

Exception: Rooms where only double-wall storage tanks conforming to Clause 4.15.9.1.3 are used to store Class I, II and IIIA flammable and combustible liquids shall not be required to have a leakage containment area.

4.15.9.1.5 Leakage alarm.

An approved automatic alarm shall be provided to indicate a leak in a storage tank and room. The alarm shall sound an audible signal, 15 dBA above the ambient sound level, at every point of entry into the room in which the leaking storage tank is located. An approved sign shall be posted on every entry door to the tank storage room indicating the potential hazard of the interior room environment, or the sign shall state: WARNING, WHEN ALARM SOUNDS, THE ENVIRONMENT WITHIN THE ROOM MAY BE HAZARDOUS. The leakage alarm shall be supervised in accordance with Part 10 to transmit a trouble signal.

4.15.9.1.6 Tank vent.

Storage tank vents for Class I, II or IIIA liquids shall terminate to the outdoor air in accordance with the Ghana Fire Code.

4.15.9.1.7 Room ventilation.

Storage tank areas storing Class I, II or IIIA liquids shall be provided with mechanical ventilation. The mechanical ventilation system shall be in accordance with the International Mechanical Code and the Ghana Fire Code.

4.15.9.1.8 Explosion venting.

Where Class I liquids are being stored, explosion venting shall be provided in accordance with the Ghana Fire Code.

4.15.9.1.9 Tank openings other than vents.

Tank openings other than vents from tanks inside buildings shall be designed to ensure that liquids or vapour concentrations are not released inside the building.

4.15.9.2 Liquefied petroleum gas facilities.

The construction and installation of liquefied petroleum gas facilities shall be in accordance with the requirements of this Code and the Ghana Fire Code.

4.15.9.3 Dry cleaning plants.

The construction and installation of dry cleaning plants shall be in accordance with the requirements of this Code. Dry cleaning solvents and systems shall be classified in accordance with the Ghana Fire Code.

4.15.10 Groups H-3 and H-4.

Groups H-3 and H-4 shall be constructed in accordance with the applicable provisions of this Code and the Ghana Fire Code.

4.15.10.1 Flammable and combustible liquids.

The storage, handling, processing and transporting of flammable and combustible liquids in Group H-3 occupancies shall be in accordance with Clause 4.15.9.1.

4.15.10.2 Gas rooms.

Where gas rooms are provided, such rooms shall be separated from other areas by not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.15.10.3 Floors in storage rooms.

Floors in storage areas for corrosive liquids and highly toxic or toxic materials shall be of liquid-tight, noncombustible construction.

4.15.10.4 Separation of highly toxic solids and liquids.

Highly toxic solids and liquids not stored in approved hazardous materials storage cabinets shall be isolated from other hazardous materials.
materials storage by not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.15.11 Group H-5.
In addition to the requirements set forth elsewhere in this Code, Group H-5 shall comply with the provisions of Clauses 4.15.11.1 through 4.15.11.11 and the Ghana Fire Code.

4.15.11.1 Fabrication areas.
Fabrication areas shall comply with Clauses 4.15.11.1.1 through 4.15.11.1.8.

4.15.11.1.1 Hazardous materials.
Hazardous materials and hazardous production materials (HPM) shall comply with Clauses 4.15.11.1.1.1 and 4.15.11.1.1.2.

4.15.11.1.1.1 Aggregate quantities.
The aggregate quantities of hazardous materials stored and used in a single fabrication area shall not exceed the quantities set forth in Table 4.15.11.1.1.1.

Exception: The quantity limitations for any hazard category in Table 4.15.11.1.1.1 shall not apply where the fabrication area contains quantities of hazardous materials not exceeding the maximum allowable quantities per control area established by Tables 3.7.1(1) and 3.7.1(2).
### TABLE 4.15.11.1.1
QUANTITY LIMITS FOR HAZARDOUS MATERIALS IN A SINGLE FABRICATION AREA IN GROUP H-5

<table>
<thead>
<tr>
<th>HAZARD CATEGORY</th>
<th>SOLIDS (pounds per square foot)</th>
<th>LIQUIDS (gallons per square foot)</th>
<th>GAS (cubic feet @ NTP/square foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLAMMABLE MATERIALS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combustible dust</td>
<td>Note b</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Combustible fiber</td>
<td>Loose Baled</td>
<td>Note b</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Notes b and c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combustible liquid</td>
<td>II</td>
<td>Not Applicable</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>IIIA</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>IIIB</td>
<td></td>
<td>Not Limited</td>
</tr>
<tr>
<td></td>
<td>Combination Class I, II and IIIA</td>
<td>Not Applicable</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>FLAMMABLE LIQUID</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable gas</td>
<td>Gaseous</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Liquefied</td>
<td></td>
<td>Note d</td>
</tr>
<tr>
<td></td>
<td>Note b</td>
<td></td>
<td>Note d</td>
</tr>
<tr>
<td><strong>FLAMMABLE SOLID</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable solid</td>
<td>0.001</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td><strong>ORGANIC PEROXIDE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unclassified</td>
<td>detonable</td>
<td>Note b</td>
<td>Note b</td>
</tr>
<tr>
<td></td>
<td>Class I</td>
<td>Note b</td>
<td>Note b</td>
</tr>
<tr>
<td></td>
<td>Class II</td>
<td>0.25</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Class III</td>
<td>0.1</td>
<td>Not Limited</td>
</tr>
<tr>
<td></td>
<td>Class IV</td>
<td>Not Limited</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class V</td>
<td>Not Limited</td>
<td></td>
</tr>
<tr>
<td><strong>OXIDIZING GAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaseous</td>
<td>Liquefied</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Note b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combination of gaseous and liquefied</td>
<td>0.1</td>
<td></td>
<td>1.25</td>
</tr>
<tr>
<td><strong>OXIDIZER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1</td>
<td>Note b</td>
<td>Note b</td>
<td>Note b</td>
</tr>
<tr>
<td>Class 2</td>
<td>0.003</td>
<td>0.03</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Class 3</td>
<td>0.003</td>
<td>0.03</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Combination Class</td>
<td>1, 2, 3</td>
<td>0.003</td>
<td>0.00125</td>
</tr>
<tr>
<td>Pyrophoric materials</td>
<td></td>
<td>0.01</td>
<td>Notes d and e</td>
</tr>
<tr>
<td><strong>UNSTABLE (REACTION)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1</td>
<td>Note b</td>
<td>Note b</td>
<td>Note b</td>
</tr>
<tr>
<td>Unstable (reactive)</td>
<td>Class 2</td>
<td>0.1</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.0025</td>
<td>Not Limited</td>
</tr>
<tr>
<td><strong>WATER REACTIVE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water reactive</td>
<td>Class 1</td>
<td>Not Limited</td>
<td>Not Limited</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td>0.25</td>
<td>0.00125</td>
</tr>
<tr>
<td></td>
<td>Class 3</td>
<td>Not Limited</td>
<td>Not Applicable</td>
</tr>
<tr>
<td><strong>HEALTH-HAZARD MATERIALS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrosives</td>
<td>Not Limited</td>
<td>Not Limited</td>
<td>Not Limited</td>
</tr>
<tr>
<td>Highly toxic</td>
<td>Not Limited</td>
<td>Not Limited</td>
<td>Note d</td>
</tr>
<tr>
<td>Toxics</td>
<td>Not Limited</td>
<td>Not Limited</td>
<td>Note d</td>
</tr>
</tbody>
</table>

Notes:
- Note a: Not LIMTED
- Note b: Not Applicable
- Note c: Calculated
- Note d: See Table 4.15.11.1.1.1
4.15.11.1.2 Hazardous production materials.

The maximum quantities of hazardous production materials (HPM) stored in a single fabrication area shall not exceed the maximum allowable quantities per control area established by Tables 3.7.1(1) and 3.7.1(2).

4.15.11.1.4 Floors.

Except for surfacing, floors within fabrication areas shall be of noncombustible construction.

Openings through floors of fabrication areas are permitted to be unprotected where the interconnected levels are used solely for mechanical equipment directly related to such fabrication areas (see Clause 4.15.11.1.5).

Floors forming a part of an occupancy separation shall be liquid tight.

4.15.11.1.5 Shafts and openings through floors.

Elevator hoistways, vent shafts and other openings through floors shall be enclosed where required by Clause 8.12 and Clause 8.13. Mechanical, duct and piping penetrations within a fabrication area shall not extend through more than two floors. The annular space around penetrations for cables, cable trays, tubing, piping, conduit or ducts shall be sealed at the floor level to restrict the movement of air. The fabrication area, including the areas through which the ductwork and piping extend, shall be considered to be a single conditioned environment.

4.15.11.1.6 Ventilation.

Mechanical exhaust ventilation at the rate of not less than 1 cubic foot per minute per square foot of floor area shall be provided throughout the portions of the fabrication area where HPM are used or stored. The exhaust air duct system of one fabrication area shall not connect to another duct system outside that fabrication area within the building.

A ventilation system shall be provided to capture and exhaust gases, fumes and vapours at workstations.

Two or more operations at a workstation shall not be connected to the same exhaust system where either one or the combination of the substances removed could constitute a fire, explosion or hazardous chemical reaction within the exhaust duct system.

Exhaust ducts penetrating fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, shall be contained in a shaft of equivalent fire-
resistance-rated construction. Exhaust ducts shall not penetrate fire walls.

Fire dampers shall not be installed in exhaust ducts.

4.15.11.1.7 Transporting hazardous production materials to fabrication areas.

HPM shall be transported to fabrication areas through enclosed piping or tubing systems that comply with Clause 4.15.11.6, through service corridors complying with Clause 4.15.11.3, or in corridors as permitted in the exception to Clause 4.15.11.2. The handling or transporting of HPM within service corridors shall comply with the Ghana Fire Code.

4.15.11.1.8 Electrical.

Electrical equipment and devices within the fabrication area shall comply with Ghana Wiring Code. The requirements for hazardous locations need not be applied where the average air change is not less than four times that set forth in Clause 4.15.11.1.6 and where the number of air changes at any location is not less than three times that required by Clause 4.15.11.1.6. The use of recirculated air shall be permitted.

4.15.11.8.1 Workstations.

Workstations shall not be energized without adequate exhaust ventilation. See Clause 4.15.11.1.6 for workstation exhaust ventilation requirements.

4.15.11.2 Corridors.

Corridors shall comply with Part 11 and shall be separated from fabrication areas as specified in Clause 4.15.11.1.2. Corridors shall not contain HPM and shall not be used for transporting such materials except through closed piping systems as provided in Clause 4.15.11.6.4.

Exception: Where existing fabrication areas are altered or modified, HPM is allowed to be transported in existing corridors, subject to the following conditions:

1. Nonproduction HPM is allowed to be transported in corridors if utilized for maintenance, lab work and testing.

2. Where existing fabrication areas are altered or modified, HPM is allowed to be transported in existing corridors, subject to the following conditions:

   2.1. Corridors. Corridors adjacent to the fabrication area where the alteration work is to be done shall comply with Clause 11.20 for a length determined as follows:

   2.1.1. The length of the common wall of the corridor and the fabrication area; and

   2.1.2. For the distance along the corridor to the point of entry of HPM into the corridor serving that fabrication area.

2.2. Emergency alarm system. There shall be an emergency telephone system, a local manual alarm station or other approved alarm-initiating device within corridors at not more than 45 720 mm (150-foot) intervals and at each exit and doorway. The signal shall be relayed to an approved central, proprietary or remote station service or the emergency control station and shall initiate a local audible alarm.

2.3. Pass-throughs. Self-closing doors having a fire protection rating of not less than 1 hour shall separate pass-throughs from existing corridors. Pass-throughs shall be constructed as required for the corridors and protected by an approved automatic sprinkler system.

4.15.11.3 Service corridors.

Service corridors within a Group H-5 occupancy shall comply with Clauses 4.15.11.3.1 through 4.15.11.3.4.

4.15.11.3.1 Use conditions.

Service corridors shall be separated from corridors as required by Clause 4.15.11.1.2. Service corridors shall not be used as a required corridor.

4.15.11.3.2 Mechanical ventilation.

Service corridors shall be mechanically ventilated as required by Clause 4.15.11.1.6 or at not less than six air changes per hour.

4.15.11.3.3 Means of escape.

The distance of travel from any point in a service corridor to an exit, exit access corridor or door into a fabrication area shall be not
greater than 22 860 mm (75 feet). Dead ends shall be not greater than 4 feet (1219 mm) in length. There shall be not less than two exits, and not more than one-half of the required means of escape shall require travel into a fabrication area. Doors from service corridors shall swing in the direction of escape travel and shall be self-closing.

4.15.11.3.4 Minimum width.
The clear width of a service corridor shall be not less than 1524 mm (5 feet), or 838 mm (33 inches) wider than the widest cart or truck used in the service corridor, whichever is greater.

4.15.11.3.5 Emergency alarm system.
Emergency alarm systems shall be provided in accordance with this clause and Clauses 4.15.5.1 and 4.15.5.2. The maximum allowable quantity per control area provisions shall not apply to emergency alarm systems required for HPM.

4.15.11.3.5.1 Service corridors.
An emergency alarm system shall be provided in service corridors, with not less than one alarm device in each service corridor.

4.15.11.3.5.2 Corridors and interior exit stairways and ramps.
Emergency alarms for corridors, interior exit stairways and ramps and exit passageways shall comply with Clause 4.15.5.2.

4.15.11.3.5.3 Liquid storage rooms, HPM rooms and gas rooms.
Emergency alarms for liquid storage rooms, HPM rooms and gas rooms shall comply with Clause 415.5.1.

4.15.11.3.5.4 Alarm-initiating devices.
An approved emergency telephone system, local alarm manual pull stations, or other approved alarm-initiating devices are allowed to be used as emergency alarm-initiating devices.

4.15.11.3.5.5 Alarm signals.
Activation of the emergency alarm system shall sound a local alarm and transmit a signal to the emergency control station.

4.15.11.4 Storage of hazardous production materials.
Storage of hazardous production materials (HPM) in fabrication areas shall be within approved or listed storage cabinets or gas cabinets or within a workstation. The storage of HPM in quantities greater than those listed in the Ghana Fire Code shall be in liquid storage rooms, HPM rooms or gas rooms as appropriate for the materials stored. The storage of other hazardous materials shall be in accordance with other applicable provisions of this Code and the Ghana Fire Code.

4.15.11.5 HPM rooms, gas rooms, liquid storage room construction.
HPM rooms, gas rooms and liquid shall be constructed in accordance with Clauses 4.15.11.5.1 through 4.15.11.5.9.

4.15.11.5.1 HPM rooms and gas rooms.
HPM rooms and gas rooms shall be separated from other areas by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. The fire-resistance rating shall be not less than 2 hours where the area is 27.9 m² (300 square feet) or more and not less than 1 hour where the area is less than 27.9 m² (300 square feet).

4.15.11.5.2 Liquid storage rooms.
Liquid storage rooms shall be constructed in accordance with the following requirements:

1. Rooms greater than 46.5 m² (500 square feet) in area, shall have not less than one exterior door approved for fire department access.

2. Rooms shall be separated from other areas by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. The fire-resistance rating shall be not less than 1 hour for rooms up to 13.9 m² (150 square feet) in area and not less than 2 hours where the room is more than 13.9 m² (150 square feet) in area.

3. Shelving, racks and wainscoting in such areas shall be of noncombustible construction or wood of not less than 25 mm (1-inch) nominal thickness or fire-
4. Rooms used for the storage of Class I flammable liquids shall not be located in a basement.

4.15.11.5.3 Floors.
Except for surfacing, floors of HPM rooms and liquid storage rooms shall be of noncombustible liquid-tight construction. Raised grating over floors shall be of noncombustible materials.

4.15.11.5.4 Location.
Where HPM rooms, liquid storage rooms and gas rooms are provided, they shall have not less than one exterior wall and such wall shall be not less than 9144 mm (30 feet) from plot lines, including plot lines adjacent to public ways.

4.15.11.5.5 Explosion control.
Explosion control shall be provided where required by Clause 4.14.5.1.

4.15.11.5.6 Exits.
Where two exits are required from HPM rooms, liquid storage rooms and gas rooms, one shall be directly to the outside of the building.

4.15.11.5.7 Doors.
Doors in a fire barrier wall, including doors to corridors, shall be self-closing fire door assemblies having a fire protection rating of not less than 3 1/4 hour.

4.15.11.5.8 Ventilation.
Mechanical exhaust ventilation shall be provided in liquid storage rooms, HPM rooms and gas rooms at the rate of not less than 0.044 L/s/m² (1 cubic foot per minute per square foot) of floor area or six air changes per hour.

Exhaust ventilation for gas rooms shall be designed to operate at a negative pressure in relation to the surrounding areas and direct the exhaust ventilation to an exhaust system.

4.15.11.5.9 Emergency alarm system.
An approved emergency alarm system shall be provided for HPM rooms, liquid storage rooms and gas rooms.

Emergency alarm-initiating devices shall be installed outside of each interior exit door of such rooms.

Activation of an emergency alarm-initiating device shall sound a local alarm and transmit a signal to the emergency control station.

An approved emergency telephone system, local alarm manual pull stations or other approved alarm-initiating devices are allowed to be used as emergency alarm-initiating devices.

4.15.11.6 Piping and tubing.
Hazardous production materials piping and tubing shall comply with this clause and ASME B31.3.

4.15.11.6.1 HPM having a health-hazard ranking of 3 or 4.
Systems supplying HPM liquids or gases having a health-hazard ranking of 3 or 4 shall be welded throughout, except for connections, to the systems that are within a ventilated enclosure if the material is a gas, or an approved method of drainage or containment is provided for the connections if the material is a liquid.

4.15.11.6.2 Location in service corridors.
Hazardous production materials supply piping or tubing in service corridors shall be exposed to view.

4.15.11.6.3 Excess flow control.
Where HPM gases or liquids are carried in pressurized piping above 103.4 kPa (15 pounds per square inch gauge (psig)), excess flow control shall be provided. Where the piping originates from within a liquid storage room, HPM room or gas room, the excess flow control shall be located within the liquid storage room, HPM room or gas room. Where the piping originates from a bulk source, the excess flow control shall be located as close to the bulk source as practical.

4.15.11.6.4 Installations in corridors and above other occupancies.
The installation of HPM piping and tubing within the space defined by the walls of corridors and the floor or roof above, or in concealed spaces above other occupancies, shall be in accordance with Clauses 4.15.11.6.1 through 4.15.11.6.3 and the following conditions:
1. Automatic sprinklers shall be installed within the space unless the space is less than 152 mm (6 inches) in the least dimension.

2. Ventilation not less than six air changes per hour shall be provided. The space shall not be used to convey air from any other area.

3. Where the piping or tubing is used to transport HPM liquids, a receptor shall be installed below such piping or tubing. The receptor shall be designed to collect any discharge or leakage and drain it to an approved location. The 1-hour enclosure shall not be used as part of the receptor.

4. HPM supply piping and tubing and nonmetallic waste lines shall be separated from the corridor and from occupancies other than Group H-5 by fire barriers or by an approved method or assembly that has a fire-resistance rating of not less than 1 hour. Access openings into the enclosure shall be protected by approved fire-protection-rated assemblies.

5. Readily accessible manual or automatic remotely activated fail-safe emergency shutoff valves shall be installed on piping and tubing other than waste lines at the following locations:

   5.1. At branch connections into the fabrication area.

   5.2. At entries into corridors.

**Exception:** Transverse crossings of the corridors by supply piping that is enclosed within a ferrous pipe or tube for the width of the corridor need not comply with Items 1 through 5.

4.15.11.6.5 Identification.
Piping, tubing and HPM waste lines shall be identified in accordance with ANSI A13.1 to indicate the material being transported.

4.15.11.7 Gas detection systems.
A gas detection system complying with Clause 916 shall be provided for HPM gases where the physiological warning threshold level of the gas is at a higher level than the accepted permissible exposure limit (PEL) for the gas and for flammable gases in accordance with Clauses 4.15.11.7.1 through 4.15.11.7.2.

4.15.11.7.1 Where required.
A gas detection system shall be provided in the areas identified in Clauses 4.15.11.7.1.1 through 4.15.11.7.1.4.

4.15.11.7.1.1 Fabrication areas.
A gas detection system shall be provided in fabrication areas where HPM gas is used in the fabrication area.

4.15.11.7.1.2 HPM rooms.
A continuous gas detection system shall be provided in HPM rooms where HPM gas is used in the room.

4.15.11.7.1.3 Gas cabinets, exhausted enclosures and gas rooms.
A gas detection system shall be provided in gas cabinets and exhausted enclosures for HPM gas. A gas detection system shall be provided in gas rooms where HPM gases are not located in gas cabinets or exhausted enclosures.

4.15.11.7.1.4 Corridors.
Where HPM gases are transported in piping placed within the space defined by the walls of a corridor and the floor or roof above the corridor, a gas detection system shall be provided where piping is located and in the corridor.

**Exception:** A gas detection system is not required for occasional transverse crossings of the corridors by supply piping that is enclosed in a ferrous pipe or tube for the width of the corridor.

4.15.11.7.2 Gas detection system operation.
The gas detection system shall be capable of monitoring the room, area or equipment in which the HPM gas is located at or below all the following gas concentrations:

1. Immediately dangerous to life and health (IDLH) values where the monitoring point is within an exhausted enclosure, ventilated enclosure or gas cabinet.

2. Permissible exposure limit (PEL) levels where the monitoring point is in an area outside an exhausted enclosure, ventilated enclosure or gas cabinet.
3. For flammable gases, the monitoring detection threshold level shall be vapour concentrations in excess of 25 percent of the lower flammable limit (LFL) where the monitoring is within or outside an exhausted enclosure, ventilated enclosure or gas cabinet.

4. Except as noted in this clause, monitoring for highly toxic and toxic gases shall also comply with the Ghana Fire Code

4.15.11.7.2.1 Alarms.

The gas detection system shall initiate a local alarm and transmit a signal to the emergency control station when a short-term hazard condition is detected. The alarm shall be both visual and audible and shall provide warning both inside and outside the area where the gas is detected. The audible alarm shall be distinct from all other alarms.

4.15.11.7.2.2 Shutoff of gas supply.

The gas detection system shall automatically close the shutoff valve at the source on gas supply piping and tubing related to the system being monitored for which gas is detected when a short-term hazard condition is detected. Automatic closure of shutoff valves shall comply with the following:

1. Where the gas detection sampling point initiating the gas detection system alarm is within a gas cabinet or exhausted enclosure, the shutoff valve in the gas cabinet or exhausted enclosure for the specific gas detected shall automatically close.

2. Where the gas detection sampling point initiating the gas detection system alarm is within a room and compressed gas containers are not in gas cabinets or an exhausted enclosure, the shutoff valves on all gas lines for the specific gas detected shall automatically close.

3. Where the gas detection sampling point initiating the gas detection system alarm is within a piping distribution manifold enclosure, the shutoff valve supplying the manifold for the compressed gas container of the specific gas detected shall automatically close.

Exception: Where the gas detection sampling point initiating the gas detection system alarm is at the use location or within a gas valve enclosure of a branch line downstream of a piping distribution manifold, the shutoff valve for the branch line located in the piping distribution manifold enclosure shall automatically close.

4.15.11.8 Manual fire alarm system.

An approved manual fire alarm system shall be provided throughout buildings containing Group H-5. Activation of the alarm system shall initiate a local alarm and transmit a signal to the emergency control station. The fire alarm system shall be designed and installed in accordance with Clause 10.7.

4.15.11.9 Emergency control station.

An emergency control station shall be provided in accordance with Clauses 4.15.11.9.1 through 4.15.11.9.3.

4.15.11.9.1 Location.

The emergency control station shall be located on the premises at an approved location outside the fabrication area.

4.15.11.9.2 Staffing.

Trained personnel shall continuously staff the emergency control station.

4.15.11.9.3 Signals.

The emergency control station shall receive signals from emergency equipment and alarm and detection systems. Such emergency equipment and alarm and detection systems shall include, but not be limited to, the following where such equipment or systems are required to be provided either in this part or elsewhere in this Code:

1. Automatic sprinkler system alarm and monitoring systems.


3. Emergency alarm systems.

4. Gas detection systems.

5. Smoke detection systems.

6. Emergency power system.

7. Automatic detection and alarm systems for pyrophoric liquids and
Class 3 water-reactive liquids required in the Ghana Fire Code.


4.15.11.10 Emergency power system.

An emergency power system shall be provided in Group H-5 occupancies in accordance with Clause 28.13. The emergency power system shall supply power automatically to the electrical systems specified in Clause 4.15.11.10.1 when the normal electrical supply system is interrupted.

4.15.11.10.1 Required electrical systems.

Emergency power shall be provided for electrically operated equipment and connected control circuits for the following systems:

1. HPM exhaust ventilation systems.
2. HPM gas cabinet ventilation systems.
3. HPM exhausted enclosure ventilation systems.
4. HPM gas room ventilation systems.
5. HPM gas detection systems.
7. Automatic sprinkler system monitoring and alarm systems.
11. Electrically operated systems required elsewhere in this Code or in the Ghana Fire Code applicable to the use, storage or handling of HPM.

4.15.11.10.2 Exhaust ventilation systems.

Exhaust ventilation systems are allowed to be designed to operate at not less than one-half the normal fan speed on the emergency power system where it is demonstrated that the level of exhaust will maintain a safe atmosphere.

4.15.11.11 Automatic sprinkler system protection in exhaust ducts for HPM.

An approved automatic sprinkler system shall be provided in exhaust ducts conveying gases, vapours, fumes, mists or dusts generated from HPM in accordance with Clauses 4.15.11.11.1 through 415.11.11.3 and the International Mechanical Code.

4.15.11.11.1 Metallic and noncombustible nonmetallic exhaust ducts.

An approved automatic sprinkler system shall be provided in metallic and noncombustible nonmetallic exhaust ducts where all of the following conditions apply:

1. Where the largest cross-clauseal diameter is equal to or greater than 254 mm (10 inches).
2. The ducts are within the building.
3. The ducts are conveying flammable gases, vapours or fumes.

4.15.11.11.2 Combustible nonmetallic exhaust ducts.

Automatic sprinkler system protection shall be provided in combustible nonmetallic exhaust ducts where the largest cross-clauseal diameter of the duct is equal to or greater than 254 mm (10 inches).

Exception: Ducts need not be provided with automatic sprinkler protection as follows:

1. Ducts listed or approved for applications without automatic sprinkler system protection.
2. Ducts not more than 3658 mm (12 feet) in length installed below ceiling level.
4.15.11.3 Automatic sprinkler locations.
Sprinkler systems shall be installed at 3658 mm (12-foot) intervals in horizontal ducts and at changes in direction. In vertical ducts, sprinklers shall be installed at the top and at alternate floor levels.

4.16 SPRAY APPLICATION OF FLAMMABLE FINISHES

4.16.1 General.
The provisions of this clause shall apply to the construction, installation and use of buildings and structures, or parts thereof, for the spray application of flammable finishes. Operations and equipment shall comply with the Ghana Fire Code.

4.16.2 Spray rooms.
Spray rooms shall be enclosed with not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11), or both. Floors shall be waterproofed and drained in an approved manner.

4.16.2.1 Construction.
Walls and ceilings of spray rooms shall be constructed of noncombustible materials or the interior surface shall be completely covered with noncombustible materials. Aluminum shall not be used.

4.16.2.2 Surfaces.
The interior surfaces of spray rooms shall be smooth and shall be so constructed to permit the free passage of exhaust air from all parts of the interior and to facilitate washing and cleaning, and shall be so designed to confine residues within the room.

4.16.3 Spraying spaces.
Spraying spaces shall be ventilated with an exhaust system to prevent the accumulation of flammable mist or vapours in accordance with this Code. Where such spaces are not separately enclosed, noncombustible spray curtains shall be provided to restrict the spread of flammable vapours.

4.16.3.1 Surfaces.
The interior surfaces of spraying spaces shall be smooth; shall be so constructed to permit the free passage of exhaust air from all parts of the interior and to facilitate washing and cleaning; and shall be so designed to confine residues within the spraying space. Aluminum shall not be used.

4.16.4 Spray booths.
Spray booths shall be designed, constructed and operated in accordance with the Ghana Fire Code.

4.16.5 Fire protection.
An automatic sprinkler system or fire-extinguishing system shall be provided in all spray rooms and spray booths, and shall be installed in accordance with Part 10.

4.17 DRYING ROOMS

4.17.1 General.
A drying room or dry kiln installed within a building shall be constructed entirely of approved noncombustible materials or assemblies of such materials regulated by the approved rules or as required in the general and specific clauses of this part for special occupancies and where applicable to the general requirements of this Code.

4.17.2 Piping clearance.
Overhead heating pipes shall have a clearance of not less than 51 mm (2 inches) from combustible contents in the dryer.

4.17.3 Insulation.
Where the operating temperature of the dryer is 79°C (175°F) or more, metal enclosures shall be insulated from adjacent combustible materials by not less than 305 mm (12 inches) of airspace, or the metal walls shall be lined with 6.4 mm ( \( \frac{3}{4} \) -inch) insulating mill board or other approved equivalent insulation.
4.17.4 Fire protection.

Drying rooms designed for high-hazard materials and processes, including special occupancies as provided for in Part 4, shall be protected by an approved automatic fire-extinguishing system complying with the provisions of Part 10.

4.18 ORGANIC COATINGS

4.18.1 Building features.

Manufacturing of organic coatings shall be done only in buildings that do not have pits or basements.

4.18.2 Location.

Organic coating manufacturing operations and operations incidental to or connected therewith shall not be located in buildings having other occupancies.

4.18.3 Process mills.

Mills operating with close clearances and that process flammable and heat-sensitive materials, such as nitrocellulose, shall be located in a detached building or noncombustible structure.

4.18.4 Tank storage.

Storage areas for flammable and combustible liquid tanks inside of structures shall be located at or above grade and shall be separated from the processing area by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.18.5 Nitrocellulose storage.

Nitrocellulose storage shall be located on a detached pad or in a separate structure or a room enclosed with not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.18.6 Finished products.

Storage rooms for finished products that are flammable or combustible liquids shall be separated from the processing area by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

4.19 LIVE/WORK UNITS

4.19.1 General.

A live/work unit shall comply with Clauses 4.19.1 through 4.19.9.

Exception: Dwelling or sleeping units that include an office that is less than 10 percent of the area of the dwelling unit are permitted to be classified as dwelling units with accessory occupancies in accordance with Clause 6.11.2.

4.19.1.1 Limitations.

All of the following shall apply to live/work areas:

1. The live/work unit is permitted to be not greater than 279 m$^2$ (3,000 square feet) in area.

2. The nonresidential area is permitted to be not more than 50 percent of the area of each live/work unit.

3. The nonresidential area function shall be limited to the first or main floor only of the live/work unit.

4. Not more than five nonresidential workers or employees are allowed to occupy the nonresidential area at any one time.

4.19.2 Occupancies.

Live/work units shall be classified as a Group R-2 occupancy. Separation requirements found in Clauses 4.20 and Clause 6.11 shall not apply within the live/work unit where the live/work unit is in compliance with Clause 4.19. Nonresidential uses that would otherwise be classified as either a Group H or S occupancy shall not be permitted in a live/work unit.

Exception: Storage shall be permitted in the live/work unit provided that the aggregate area of storage in the nonresidential portion of the live/work unit shall be limited to 10 percent of the space dedicated to nonresidential activities.

4.19.3 Means of escape.

Except as modified by this clause, the means of escape components for a live/work unit shall be designed in accordance with Part 11 for the function served.
4.19.3.1 Escape capacity.
The escape capacity for each element of the live/work unit shall be based on the occupant load for the function served in accordance with Table 11.4.5.

4.19.3.2 Spiral stairways.
spiral stairways that conform to the requirements of Clause 11.11.10 shall be permitted.

4.19.4 Vertical openings.
Floor openings between floor levels of a live/work unit are permitted without enclosure.

4.19.5 Fire protection.
The live/work unit shall be provided with a monitored fire alarm system where required by Clause 10.7.2.9 and an automatic sprinkler system in accordance with Clause 10.3.2.8.

4.19.6 Structural.
Floors within a live/work unit shall be designed for the live loads in this code based on the function within the space.

4.19.7 Accessibility.
Accessibility shall be designed in accordance with Part 12 for the function served.

4.19.8 Ventilation.
The applicable ventilation requirements of this Code shall apply to each area within the live/work unit for the function within that space.

4.19.9 Plumbing facilities.
The nonresidential area of the live/work unit shall be provided with minimum plumbing facilities as specified by Part 30, based on the function of the nonresidential area. Where the nonresidential area of the live/work unit is required to be accessible by this Code the plumbing fixtures specified by Part 30 shall be accessible.

4.20 GROUPS I-1, R-1, R-2, R-3 AND R-4

4.20.1 General.
Occupancies in Groups I-1, R-1, R-2, R-3 and R-4 shall comply with the provisions of Clauses 4.20.1 through 4.20.10 and other applicable provisions of this Code.

4.20.2 Separation walls.
Walls separating dwelling units in the same building, walls separating sleeping units in the same building and walls separating dwelling or sleeping units from other occupancies contiguous to them in the same building shall be constructed as fire partitions in accordance with Clause 8.8.

Exceptions:
1. Where sleeping units include private bathrooms, walls between bedrooms and the associated private bathrooms are not required to be constructed as fire partitions.
2. Where sleeping units are constructed as suites, walls between bedrooms within the sleeping unit and the walls between the bedrooms and associated living spaces are not required to be constructed as fire partitions.
3. In Group R-3 and R-4 facilities, walls within the dwelling units or sleeping units are not required to be constructed as fire partitions.

4.20.3 Horizontal separation.
Floor assemblies separating dwelling units in the same buildings, floor assemblies separating sleeping units in the same building and floor assemblies separating dwelling or sleeping units from other occupancies contiguous to them in the same building shall be constructed as horizontal assemblies in accordance with Clause 8.11.

Exception: In Group R-3 and R-4 facilities, floor assemblies within the dwelling units or sleeping units are not required to be constructed as horizontal assemblies.

4.20.4 Automatic sprinkler system.
Group R occupancies shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.8. Group I-1 occupancies shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.6. Quick-response or residential automatic sprinklers shall be installed in accordance with Clause 10.3.3.2.

4.20.5 Fire alarm systems and smoke alarms.
Fire alarm systems and smoke alarms shall be provided in Group I-1, R-1 and R-2 occupancies in accordance with Clause
10.7.2.6, 10.7.2.8 and 10.7.2.9 respectively. Single- or multiple-station smoke alarms shall be provided in Groups I-1, R-2, R-3 and R-4 in accordance with Clause 10.7.2.10.

4.20.6 Smoke barriers in Group I-1, Condition 2.

Smoke barriers shall be provided in Group I-1, Condition 2 to subdivide every storey used by persons receiving care, treatment or sleeping and to provide other stories with an occupant load of 50 or more persons, into not fewer than two smoke compartments. Such stories shall be divided into smoke compartments with an area of not more than 2092 m$^2$ (22,500 square feet) and the distance of travel from any point in a smoke compartment to a smoke barrier door shall not exceed 60 960 mm (200 feet). The smoke barrier shall be in accordance with Clause 8.9.

4.20.6.1 Refuge area.

Refuge areas shall be provided within each smoke compartment. The size of the refuge area shall accommodate the occupants and care recipients from the adjoining smoke compartment. Where a smoke compartment is adjoined by two or more smoke compartments, the minimum area of the refuge area shall accommodate the largest occupant load of the adjoining compartments. The size of the refuge area shall provide the following:

1. Not less than 1.4 m$^2$ (15 net square feet) for each care recipient.
2. Not less than 0.56 m$^2$ (6 net square feet) for other occupants.

Areas or spaces permitted to be included in the calculation of the refuge area are corridors, lounge or dining areas and other low-hazard areas.

4.20.7 Group I-1 assisted living housing units.

In Group I-1 occupancies, where a fire-resistance corridor is provided in areas where assisted living residents are housed, shared living spaces, group meeting or multipurpose therapeutic spaces open to the corridor shall be in accordance with all of the following criteria:

1. The walls and ceilings of the space are constructed as required for corridors.
2. The spaces are not occupied as resident sleeping rooms, treatment rooms, incidental uses in accordance with Clause 6.12 or hazardous uses.
3. The open space is protected by an automatic fire detection system installed in accordance with Clause 10.7.
4. In Group I-1, Condition 1, the corridors onto which the spaces open are protected by an automatic fire detection system installed in accordance with Clause 10.7, or the spaces are equipped throughout with quick-response sprinklers in accordance with Clause 10.3.3.2.
5. In Group I-1, Condition 2, the corridors onto which the spaces open, in the same smoke compartment, are protected by an automatic fire detection system installed in accordance with Clause 10.7, or the smoke compartment in which the spaces are located is equipped throughout with quick-response sprinklers in accordance with Clause 10.3.3.2.
6. The space is arranged so as not to obstruct access to the required exits.

4.20.8 Group I-1 cooking facilities.

In Group I-1 occupancies, rooms or spaces that contain cooking facilities with domestic cooking appliances shall be in accordance with all of the following criteria:

1. In Group I-1, Condition 1 occupancies, the number of care recipients served by one cooking facility shall not be greater than 30.
2. In Group I-1, Condition 2 occupancies, the number of care recipients served by one cooking facility and within the same smoke compartment shall not be greater than 30.
3. The types of domestic cooking appliances permitted shall be limited to ovens, cooktops, ranges, warmers and microwaves.
4. The space containing the domestic cooking facilities shall be arranged so as not to obstruct access to the required exit.

5. Domestic cooking hoods installed and constructed in accordance with Clause 505 of the International Mechanical Code shall be provided over cooktops or ranges.

6. Cooktops and ranges shall be protected in accordance with Clause 10.4.13.

7. A shutoff for the fuel and electrical supply to the cooking equipment shall be provided in a location that is accessible only to staff.

8. A timer shall be provided that automatically deactivates the cooking appliances within a period of not more than 120 minutes.

9. A portable fire extinguisher shall be provided. Installation shall be in accordance with Clause 10.6 and the extinguisher shall be located within a 9144 mm (30-foot) distance of travel from each domestic cooking appliance.

4.20.8.1 Cooking facilities open to the corridor.
Cooking facilities located in a room or space open to a corridor, aisle or common space shall comply with Clause 4.20.8.

4.20.9 Group R cooking facilities.
In Group R occupancies, cooking appliances used for domestic cooking operations shall be in accordance with this Code.

4.20.10 Group R-2 dormitory cooking facilities.
Domestic cooking appliances for use by residents of Group R-2 college dormitories shall be in accordance with Clauses 4.20.10.1 and 4.20.10.2.

4.20.10.1 Cooking appliances.
Where located in Group R-2 college dormitories, domestic cooking appliances for use by residents shall be in compliance with all of the following:

1. The types of domestic cooking appliances shall be limited to ovens, cooktops, ranges, warmers, coffee makers and microwaves.

2. Domestic cooking appliances shall be limited to approved locations.

3. Cooktops and ranges shall be protected in accordance with Clause 10.4.13.

4. Cooktops and ranges shall be provided with a domestic cooking hood installed and constructed in accordance with this Code.

4.20.10.2 Cooking appliances in sleeping rooms.
Cooktops, ranges and ovens shall not be installed or used in sleeping rooms.

4.21 HYDROGEN FUEL GAS ROOMS

4.21.1 General.
Where required by the Ghana Fire Code, hydrogen fuel gas rooms shall be designed and constructed in accordance with Clauses 4.21.1 through 4.21.7.

4.21.2 Location.
Hydrogen fuel gas rooms shall not be located below grade.

4.21.3 Design and construction.
Hydrogen fuel gas rooms not classified as Group H shall be separated from other areas of the building in accordance with Clause 6.12.1.

4.21.3.1 Pressure control.
Hydrogen fuel gas rooms shall be provided with a ventilation system designed to maintain the room at a negative pressure in relation to surrounding rooms and spaces.

4.21.3.2 Windows.
Operable windows in interior walls shall not be permitted. Fixed windows shall be permitted where in accordance with Clause 8.16.

4.21.4 Exhaust ventilation.
Hydrogen fuel gas rooms shall be provided with mechanical exhaust ventilation in accordance with the applicable provisions of this Code.

4.21.5 Gas detection system.
Hydrogen fuel gas rooms shall be provided with a gas detection system that complies with Clauses 4.21.5.1, 4.21.5.2, and 10.16.

4.21.5.1 System activation.
Activation of a gas detection alarm shall result in both of the following:
1. Initiation of distinct audible and visible alarm signals both inside and outside of the hydrogen fuel gas room.

2. Automatic activation of the mechanical exhaust ventilation system.

4.21.5.2 Failure of the gas detection system. Failure of the gas detection system shall automatically activate the mechanical exhaust ventilation system, stop hydrogen generation, and cause a trouble signal to sound at an approved location.

4.21.6 Explosion control. Explosion control shall be provided where required by Clause 4.14.5.1.

4.21.7 Standby power. Mechanical ventilation and gas detection systems shall be provided with a standby power system in accordance with Clause 28.13.

4.22 AMBULATORY CARE FACILITIES

4.22.1 General. Occupancies classified as ambulatory care facilities shall comply with the provisions of Clauses 4.22.1 through 4.22.6 and other applicable provisions of this Code.

4.22.2 Separation. Ambulatory care facilities where the potential for four or more care recipients are to be incapable of self-preservation at any time shall be separated from adjacent spaces, corridors or tenants with a fire partition installed in accordance with Clause 8.8.

4.22.3 Smoke compartments. Where the aggregate area of one or more ambulatory care facilities is greater than 929 m² (10,000 square feet) on one storey, the storey shall be provided with a smoke barrier to subdivide the storey into not fewer than two smoke compartments. The area of any one such smoke compartment shall be not greater than 2092 m² (22,500 square feet). The distance of travel from any point in a smoke compartment to a smoke barrier door shall be not greater than 60 960 mm (200 feet). The smoke barrier shall be installed in accordance with Clause 8.9 with the exception that smoke barriers shall be continuous from outside wall to an outside wall, a floor to a floor, or from a smoke barrier to a smoke barrier or a combination thereof.

4.22.3.1 Means of escape. Where ambulatory care facilities require smoke compartmentation in accordance with Clause 4.22.3, the fire safety evacuation plans provided in accordance with Clause 11.2.2 shall identify the building components necessary to support a defend-in-place emergency response in accordance with the Ghana Fire Code.

4.22.3.2 Refuge area. Not less than 2.8 m² (30 net square feet) for each nonambulatory care recipient shall be provided within the aggregate area of corridors, care recipient rooms, treatment rooms, lounge or dining areas and other low-hazard areas within each smoke compartment. Each occupant of an ambulatory care facility shall be provided with access to a refuge area without passing through or utilizing adjacent tenant spaces.

4.22.3.3 Independent escape. A means of escape shall be provided from each smoke compartment created by smoke barriers without having to return through the smoke compartment from which means of escape originated.

4.22.4 Automatic sprinkler systems. Automatic sprinkler systems shall be provided for ambulatory care facilities in accordance with Clause 10.3.2.2.

4.22.5 Fire alarm systems. A fire alarm system shall be provided for ambulatory care facilities in accordance with 10.7.2.2.

4.22.6 Electrical systems. In ambulatory care facilities, the essential electrical system for electrical components, equipment and systems shall be designed and constructed in accordance with the provisions of Part 28.
4.23 STORM SHELTERS

4.23.1 General.
This clause applies to the construction of storm shelters constructed as separate detached buildings or constructed as rooms or spaces within buildings for the purpose of providing protection from storms that produce high winds, such as tornadoes and hurricanes during the storm. Such structures shall be designated to be hurricane shelters, tornado shelters, or combined hurricane and tornado shelters. Design of facilities for use as emergency shelters after the storm are outside the scope of ICC 500 and shall comply with this Code.

4.23.2 Construction.
In addition to other applicable requirements in this Code, storm shelters shall be constructed in accordance with ICC 500. Buildings or structures that are also designated as emergency shelters shall also comply with this Code.

4.23.3 Critical emergency operations.
In areas where the shelter design wind speed for tornadoes in accordance with Figure 304.2(1) of ICC 500 is 250 mph, 911 call stations, emergency operation centers and fire, rescue, ambulance and police stations shall comply with this Code and shall be provided with a storm shelter constructed in accordance with ICC 500.

4.23.4 Group E occupancies.
In areas where the shelter design wind speed for tornadoes is 250 mph in accordance with Figure 304.2(1) of ICC 500, all Group E occupancies with an occupant load of 50 or more shall have a storm shelter constructed in accordance with ICC 500.

Exceptions:
1. Group E day care facilities.
2. Group E occupancies accessory to places of religious worship.
3. Buildings meeting the requirements for shelter design in ICC 500.

4.23.4.1 Required occupant capacity.
The required occupant capacity of the storm shelter shall include all of the buildings on the site and shall be the greater of the following:

1. The total occupant load of the classrooms, vocational rooms and offices in the Group E occupancy.
2. The occupant load of any indoor assembly space that is associated with the Group E occupancy.

Exceptions:
1. Where a new building is being added on an existing Group E site, and where the new building is not of sufficient size to accommodate the required occupant capacity of the storm shelter for all of the buildings on the site, the storm shelter shall at a minimum accommodate the required occupant capacity for the new building.
2. Where approved by the Code official, the required occupant capacity of the shelter shall be permitted to be reduced by the occupant capacity of any existing storm shelters on the site.

4.23.4.2 Location.
Storm shelters shall be located within the buildings they serve or shall be located where the maximum distance of travel from not fewer than one exterior door of each building to a door of the shelter serving that building does not exceed 305 m (1,000 feet).

4.24 CHILDREN’S PLAY STRUCTURES

4.24.1 General.
Children’s play structures installed inside all occupancies covered by this Code that exceed 3048 mm (10 feet) in height or 14 m² (150 square feet) in area shall comply with Clauses 4.24.2 through 4.24.5.

4.24.2 Materials.
Children’s play structures shall be constructed of noncombustible materials or of combustible materials that comply with the following:

1. Fire-retardant-treated wood complying with Clause 24.3.2
2. Light-transmitting plastics complying with Clause 27.6.
3. Foam plastics (including the pipe foam used in soft-contained play equipment structures) having a maximum heat-release rate not greater than 100 kilowatts when tested in accordance
with UL 1975 or when tested in accordance with NFPA 289, using the 20 kW ignition source.

4. Aluminum composite material (ACM) meeting the requirements of Class A interior finish in accordance with Part 9 when tested as an assembly in the maximum thickness intended for use.

5. Textiles and films complying with the fire propagation performance criteria contained in Test Method 1 or Test Method 2, as appropriate, of ASTM E84

6. Plastic materials used to construct rigid components of soft-contained play equipment structures (such as tubes, windows, panels, junction boxes, pipes, slides and decks) exhibiting a peak rate of heat release not exceeding 400 kW/m² when tested in accordance with ASTM E1354 at an incident heat flux of 50 kW/m² in the horizontal orientation at a thickness of 6 mm.

7. Ball pool balls, used in soft-contained play equipment structures, having a maximum heat-release rate not greater than 100 kilowatts when tested in accordance with UL 1975 or when tested in accordance with this code, using the 20 kW ignition source. The minimum specimen test size shall be 36 inches by 36 inches (914 mm by 914 mm) by an average of 21 inches (533 mm) deep, and the balls shall be held in a box constructed of galvanized steel poultry netting wire mesh.

8. Foam plastics shall be covered by a fabric, coating or film meeting the fire propagation performance criteria contained in Test Method 1 or Test Method 2, as appropriate, of this Code.

9. The floor covering placed under the children’s play structure shall exhibit a Class I interior floor finish classification, as described in Clause 9.4, when tested in accordance with ASTM E648

4.24.3 Fire protection.
Children’s play structures shall be provided with the same level of approved fire suppression and detection devices required for other structures in the same occupancy.

4.24.4 Separation.
Children’s play structures shall have a horizontal separation from building walls, partitions and from elements of the means of escape of not less than 1524 mm (5 feet). Children’s playground structures shall have a horizontal separation from other children’s play structures of not less than 6090 mm (20 feet).

4.24.5 Area limits.
Children’s play structures shall be not greater than 28 m² (300 square feet) in area, unless a special investigation, acceptable to the building official, has demonstrated adequate fire safety.

4.25 HYPERBARIC FACILITIES

4.25.1 Hyperbaric facilities.
Hyperbaric facilities shall meet the requirements contained in the Ghana Fire Code.

4.26 COMBUSTIBLE DUSTS, GRAIN PROCESSING AND STORAGE

The provisions of Clauses 4.26.1.1 through 4.26.1.7 shall apply to buildings in which materials that produce combustible dusts are stored or handled. Buildings that store or handle combustible dusts shall comply with the Ghana Fire Code.

4.26.1.1 Type of construction and height exceptions.
Buildings shall be constructed in compliance with the height, number of stories and area limitations specified in Clause 6.4 and 6.9; except that where erected of Type I or II construction, the heights and areas of grain elevators and similar structures shall be unlimited, and where of Type IV construction, the maximum building height shall be 19 812 mm (65 feet) and except further that, in isolated areas, the maximum building height of Type IV structures shall be increased to 25 908 mm (85 feet).

4.26.1.2 Grinding rooms.
Every room or space occupied for grinding or other operations that produce combustible dusts in such a manner that the room or space is classified as a Group H-2 occupancy shall be
enclosed with fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. The fire-resistance rating of the enclosure shall be not less than 2 hours
\[ \text{where the area is not more than } 279 \, \text{m}^2 (3,000 \, \text{square feet}), \text{and not less than } 4 \text{ hours where} \]
\[ \text{the area is greater than } 279 \, \text{m}^2 (3,000 \, \text{square feet}). \]

4.26.1.3 Conveyors.
Conveyors, chutes, piping and similar equipment passing through the enclosures of rooms or spaces shall be constructed dirt tight and vapour tight, and be of approved noncombustible materials complying with Part 31.

4.26.1.4 Explosion control.
Explosion control shall be provided as specified in the Ghana Fire Code, or spaces shall be equipped with the equivalent mechanical ventilation complying with this Code.

4.26.1.5 Grain elevators.
Grain elevators, malt houses and buildings for similar occupancies shall not be located within 9144 mm (30 feet) of interior plot lines or structures on the same plot, except where erected along a railroad right-of-way.

4.26.1.6 Coal pockets.
Coal pockets located less than 9144 mm (30 feet) from interior plot lines or from structures on the same plot shall be constructed of not less than Type IB construction. Where more than 9144 mm (30 feet) from interior plot lines, or where erected along a railroad right-of-way, the minimum type of construction of such structures not more than 19,812 mm (65 feet) in building height shall be Type III.

4.26.1.7 Tire rebuilding.
Buffing operations shall be located in a room separated from the remainder of the building housing the tire rebuilding or tire recapping operation by a 1-hour fire barrier.

**Exception:** Buffing operations are not required to be separated where all of the following conditions are met:

1. Buffing operations are equipped with an approved continuous automatic water-spray system directed at the point of cutting action.
2. Buffing machines are connected to particle-collecting systems providing a minimum air movement of 1,500 cubic feet per minute (cfm) (0.713 m³/s) in volume and 4,500 feet per minute (fpm) (23 m/s) in-line velocity.
3. The collecting system shall discharge the rubber particles to an approved outdoor noncombustible or fire-resistant container, which is emptied at frequent intervals to prevent overflow.

4.27 MEDICAL GAS SYSTEMS

4.27.1 General.
Medical gases at health care-related facilities intended for patient or veterinary care shall comply with Clauses 4.27.2 through 4.27.2.3 in addition to requirements of the Ghana Fire Code.

4.27.2 Interior supply location.
Medical gases shall be located in areas dedicated to the storage of such gases without other storage or uses. Where containers of medical gases in quantities greater than the permitted amount are located inside the buildings, they shall be located in a 1-hour exterior room, 1-hour interior room or a gas cabinet in accordance with Clause 4.27.2.1, 4.27.2.2 or 4.27.2.3, respectively. Rooms or areas where medical gases are stored or used in quantities exceeding the maximum allowable quantity per control area as set forth in Tables 307.1(1) and 307.1(2) shall be in accordance with Group H occupancies.

4.27.2.1 One-hour exterior room.
A 1-hour exterior room shall be a room or enclosure separated from the remainder of the building by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both, with a fire-resistance rating of not less than 1 hour. Openings
between the room or enclosure and interior spaces shall be provided with self-closing smoke- and draft-control assemblies having a fire protection rating of not less than 1 hour. Rooms shall have not less than one exterior wall that is provided with not less than two vents. Each vent shall have a minimum free air opening of not less than 232 cm² (36 square inches) for each 28 m³ (1,000 cubic feet) at normal temperature and pressure (NTP) of gas stored in the room and shall be not less than 465 cm² (72 square inches) in aggregate free opening area. One vent shall be within 152 mm (6 inches) of the floor and one shall be within 152 mm (6 inches) of the ceiling. Rooms shall be provided with not less than one automatic fire sprinkler to provide container cooling in case of fire.

4.27.2.2 One-hour interior room.

Where an exterior wall cannot be provided for the room, a 1-hour interior room or enclosure shall be provided and separated from the remainder of the building by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both, with a fire-resistance rating of not less than 1 hour. Openings between the room or enclosure and interior spaces shall be provided with self-closing smoke- and draft-control assemblies having a fire protection rating of not less than 1 hour. An automatic sprinkler system shall be installed within the room. The room shall be exhausted through a duct to the exterior. Supply and exhaust ducts shall be enclosed in a 1-hour rated shaft enclosure from the cabinet to the exterior. The average velocity of ventilation at the face of access ports or windows shall be not less than 1.02 m/s (200 feet per minute) with a minimum of 0.76 m/s (150 feet per minute) at any point of the access port or window.

3. Cabinets shall be provided with an automatic sprinkler system internal to the cabinet.

4.28 HIGHER EDUCATION LABORATORIES

4.28.1 Scope.

Higher education laboratories complying with the requirements of Clauses 4.28.1 through 4.28.4 shall be permitted to exceed the maximum allowable quantities of hazardous materials in control areas set forth in Tables 3.7.1(1) and 3.7.1(2) without requiring classification as a Group H occupancy. Except as specified in Clause 4.28, such laboratories shall comply with all applicable provisions of this Code and the Ghana Fire Code.

4.28.2 Application.

The provisions of Clause 4.28 shall be applied as exceptions or additions to applicable requirements of this Code. Unless specifically modified by Clause 4.28, the storage, use and handling of hazardous materials shall comply with all other provisions in the Ghana Fire Code and this Code for quantities not exceeding the maximum allowable quantity.

4.28.3 Laboratory suite construction.

Where laboratory suites are provided, they shall be constructed in accordance with this clause and the Ghana Fire Code. The number of laboratory suites and percentage of maximum allowable quantities of hazardous materials in laboratory suites shall be in accordance with Table 4.28.3.
[F] TABLE 4.28.3
DESIGN AND NUMBER OF LABORATORY SUITES PER FLOOR

<table>
<thead>
<tr>
<th>FLOOR LEVEL</th>
<th>PERCENTAGE OF THE MAXIMUM ALLOWABLE QUANTITY PER LAB SUITE a</th>
<th>NUMBER OF LAB SUITES PER FLOOR</th>
<th>FIRE-RESISTANCE RATING FOR FIRE BARRIERS IN b HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Grade Plane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21+</td>
<td>Not allowed</td>
<td>Not Permitted</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>16-20</td>
<td>25</td>
<td>1</td>
<td>2²</td>
</tr>
<tr>
<td>11-15</td>
<td>50</td>
<td>1</td>
<td>2²</td>
</tr>
<tr>
<td>7-10</td>
<td>50</td>
<td>2</td>
<td>2²</td>
</tr>
<tr>
<td>4-6</td>
<td>75</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1-2</td>
<td>100</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Below Grade Plane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>75</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Lower than 2</td>
<td>Not Allowed</td>
<td>Not Allowed</td>
<td>Not Allowed</td>
</tr>
</tbody>
</table>

a. Percentages shall be of the maximum allowable quantity per control area shown in Tables 3.7.1(1) and 3.7.1(2), with all increases allowed in the footnotes to those tables.
b. Fire barriers shall include walls, floors and ceilings necessary to provide separation from other portions of the building.
c. Vertical fire barriers separating laboratory suites from other spaces on the same floor shall be permitted to be 1-hour fire-resistance rated.

4.28.3.1 Separation from other nonlaboratory areas.
Laboratory suites shall be separated from other portions of the building in accordance with the most restrictive of the following:

1. Fire barriers and horizontal assemblies as required in Table 4.28.3. Fire barriers shall be constructed in accordance with Clause 8.7 and horizontal assemblies constructed in accordance with Clause 8.11.

Exception: Where an individual laboratory suite occupies more than one storey, the fire-resistance rating of intermediate floors contained within the laboratory suite shall comply with the requirements of this Code.

2. Separations as required by Clause 6.11.

4.28.3.2 Separation from other laboratory suites.
Laboratory suites shall be separated from other laboratory suites in accordance with Table 4.28.3.

4.28.3.3 Floor assembly fire resistance.
The floor assembly supporting laboratory suites and the construction supporting the floor of laboratory suites shall have a fire resistance rating of not less than 2 hours.

Exception: The floor assembly of the laboratory suites and the construction supporting the floor of the laboratory suites are allowed to be 1-hour fire-resistance rated in buildings of Types IIA, IIIA and VA construction, provided that the building is three or fewer stories.

4.28.3.4 Maximum number.
The maximum number of laboratory suites shall be in accordance with Table 4.28.3. Where a building contains both laboratory suites and control areas, the total number of laboratory suites and control areas within a building shall not exceed the maximum number of laboratory suites in accordance with Table 4.28.3.

4.28.3.5 Means of escape.
Means of escape shall be in accordance with Part 11.

4.28.3.6 Standby or emergency power.
Standby or emergency power shall be provided in accordance with Clause 4.14.5.2 where laboratory suites are located above the sixth storey above grade plane or located in a storey below grade plane.
4.28.7 Ventilation.
Ventilation shall be in accordance with this Code.

4.28.8 Liquid-tight floor.
Portions of laboratory suites where hazardous materials are present shall be provided with a liquid-tight floor.

4.28.9 Automatic fire-extinguishing systems.
Buildings containing laboratory suites shall be equipped throughout with an approved automatic sprinkler system in accordance with Clause 10.3.3.1.1.

4.28.4 Percentage of maximum allowable quantity in each laboratory suite.
The percentage of maximum allowable quantities of hazardous materials in each laboratory suite shall be in accordance with Table 4.28.3.
PART 5: SITE DEVELOPMENT AND LAND USE

5.1 GENERAL

5.1.1 Scope

This part provides requirements for land use, development and maintenance of building and building sites to minimize negative environmental impacts and to protect, restore and enhance the natural features and environmental quality of the site.

5.2 LAND USE CLASSIFICATION AND USES PERMITTED

5.2.1 Land Use Classification

The various land use classifications may be as indicated below:

a) Residential zone
   - Purely residential (R_1)
   - Residential with shop lines at ground floor (R_2)

b) Commercial zone
   - Local commercial area (C_1)
   - District commercial area (C_2)

c) Industrial zone
   - Service industries (I_1)
   - General industries (I_2)
   - Special industries (I_3)

d) Green zone

e) Special reservations


5.2.1.1 The various building uses and occupancies permitted on the various zones shall be as given in the Development Master Plan.

5.2.1.2 Uses to be in Conformity with the Zone

Where the use of buildings or premises is not specifically designated on the development plan, it shall be in conformity with the zone in which they fall.

5.2.1.3 Uses as Specifically Designated on Development Plan

Where the use of a site is specifically designated on the Development Plan, it shall be used only for the purpose so designated.

5.2.1.4 Non-conforming

Uses – No plot shall be put to any use, occupancy or premises other than the uses identified in Clause 5.2.1, except with the prior approval of the Authority.

5.3 MEANS OF ACCESS

5.3.1 Every building/plot shall abut on a public/private means of access like streets/roads duly formed.

5.3.2 Every person who erects a building shall not at any time erect or cause or permit to erect any building which in any way encroaches upon or diminishes the area set apart as means of access (including bicycle lanes) required in this Code. No building shall be erected so as to deprive any other building of the means of access.

5.3.3 Width of Means of Access

The residential plots shall abut on a public means of access like street/road. Plots which do not abut on a street/road shall abut/front on a means of access, the width and other requirements of which shall be as given in Table 5.1.

In no case, shall development on plots be permitted unless it is accessible by a public street of width not less than 6m.

Table 5.1 - Width and Length of Means of Access

<table>
<thead>
<tr>
<th>Row No.</th>
<th>Width of Means of Access m</th>
<th>Length of Means of Access m</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>6.0</td>
<td>75</td>
</tr>
</tbody>
</table>
5.3.3.1 Other Buildings

For all the industrial buildings, theatres, cinema houses, assembly halls, stadia, educational buildings, markets, other buildings which attract large crowd, the means of access shall not be less than the following:

<table>
<thead>
<tr>
<th>Width of Means of Access (m)</th>
<th>Length of Means of Access (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.0</td>
<td>200</td>
</tr>
<tr>
<td>15.0</td>
<td>400</td>
</tr>
<tr>
<td>18.0</td>
<td>600</td>
</tr>
<tr>
<td>24.0</td>
<td>Above 600</td>
</tr>
</tbody>
</table>

Further, in no case shall the means of access be lesser in width than the internal access ways in layouts and subdivisions.

5.3.3.2 - Pathways

The approach to the buildings from road/street/internal means of access shall be through paved pathway of width not less than 1.5m, provided its length is not more than 3.0m.

5.3.3.2.1 In the case of special housing schemes for low income group and economically weaker Clause of society developed up to two storeyed row/cluster housing scheme, the pedestrian pathway width shall be 3m subject to provisions of Clause 6.5.4.1(a). The pedestrian pathway shall not serve more than 8 plots on each side of the pathway; the length of the pathway shall be not more than 50m.

5.3.3.3 The length of the main means of access shall be determined by the distance from the farthest plot (building) to the public street. The length of the subsidiary access way shall be measured from the point of its origin to the next wider road on which it meets.

5.3.3.4 In the interest of general development of an area, the Authority may require the means of access to be of larger width than that required under Clause 5.3.3 and 5.3.3.1.

5.3.3.5 In existing built-up areas in the case of plots facing street/means of access less than 4.5m in width, the plot boundary shall be shifted to be away by 2.25m from the central line of the street/means of access way of 4.5m width.

5.3.4 The means of access shall be leveled, metalled, flagged, paved, sewered, drained, channeled, lighted, laid with water supply line and provided with trees for shade to the satisfaction of the Authority free of encroachment by any structure or fixtures so as not to reduce its width below the minimum required under Clause 5.3.3 and shall be maintained in a condition to the satisfaction of the Authority.

5.3.4.1 If any private street or any other means of access to a building is not leveled, metalled, flagged or paved, sewered, drained, channeled, lighted or laid with water supply line or provided with trees for shade to the satisfaction of the Authority, who may, with the sanction of the Authority, by written notice require the owner or owners of the several premises fronting or adjoining the said street or other means of access or abutting thereon or to which access is obtained through such street or other means of access or which shall benefit by works executed, to carry out any or more of the aforesaid requirements in such manner as he shall direct.

5.3.4.2 If any structure or fixture is set upon a means of access so as to reduce its width below the minimum required, the Authority may remove the same further and recover the expenses so incurred from the owner.
5.3.5 Access from Highways/Important Roads

No premises other than highway amenities like petrol pumps, motels, etc. shall have an access direct from highways and such other roads not less than 52m in width, which the Authority with the approval of the Highway Authority shall specify from time to time. The Authority shall maintain a register of such roads which shall be open to public inspection at all times during office hours. The portion of such roads on which direct access may be permitted shall be as identified in the Development Plan. However, in the case of existing development on highways/other roads referred to above, the operation of this clause shall be exempted. These provisions shall, however, be subject to the provisions of the relevant National Highway Act.

5.3.6 For high rise buildings and buildings other than residential, the following additional provisions of means of access shall be ensured:

a) The width of the main street on which the building abuts shall not be less than 12m and one end of this street shall join another street not less than 12m in width.

b) The approach to the building and open spaces on all its sides up to 6m width and the layout for the same shall be done in consultation with the Chief Fire Officer of the city and the same shall be hard surface capable of taking the weight of fire engine, weighing up to 18 tonnes. The said open space shall be kept free of obstructions and shall be motorable.

c) The main entrance to the plot shall be of adequate width to allow easy access to the fire engine and in no case shall it measure less than 4.5m. The entrance gate shall fold back against the compound wall of the premises, thus leaving exterior accessway within the plot free for movement of fire service vehicle. If the main entrance at the boundary wall is built over, the minimum clearance shall be 4.5m.

5.3.7 Cul-de-sacs giving access to plots and extending from 150 to 275m in length with an additional turning space at 150m will be allowed only in residential areas, provided cul-de-sacs would be permissible only on straight roads and further provided the end of cul-de-sacs shall be higher in level than the level of the starting point of such dead end road. The turning space in this case shall be not less than 81 m in area, with no dimension less than 9m.

5.3.8 InterClause of Roads

For interClause junctions of roads meeting at right angles as well as other roads meeting at right angles as well as other than rights angles, the rounding off or cut off or splay or similar treatment shall be done, to the approval of the Authority, depending upon the width of roads, the traffic generated, the sighting angle, etc. to provide clear sight distance.

5.3.9 The building line shall be set back at least 3m from internal means of access in a layout of buildings in a plot subject to provisions of Clause 5.6.2.1.

5.4 COMMUNITY OPEN/SOCIAL SPACES AND AMENITIES

5.4.1 Residential and Commercial Zones

In any layout or sub-division of land measuring 0.3 hectare of more in residential and commercial zones, the community open spaces shall be reserved for recreational purposes which shall as far as possible be provided in one place or planned out for the use of the community in clusters or pockets.

5.4.1.1 The community open spaces shall be provided catering to the needs of area of layout, population for which the layout is planned and the category of dwelling units. The following minimum provision shall be made:

a) 15 percent of the area of the layout, or

b) 0.3 to 0.4 ha/1000 persons; for low income housing the open spaces
shall be 0.3 ha/1000 persons.

5.4.2 No recreational space shall generally be less than 450 m².

5.4.2.1 The minimum average dimension of such recreational space shall be not less than 7.5m; if the average width of such recreational space is less than 24m, the length thereof shall not exceed 2.5 times the average width. However, depending on the configuration of the site, commonly open spaces of different shapes may be permitted by the Authority, as long as the open spaces provided serve the needs of the immediate community contiguous to the open spaces.

5.4.2.2 In such recreational spaces, a single storeyed structure as pavilion or gymnasium up to 25m² in area may be permitted; such area may be excluded from FAR calculations; no toilet block shall be permitted.

5.4.3 Each recreational area and the structure on it shall have an independent means of access. Independent means of access may not be insisted upon if recreational space is approachable directly from every building in the layout. Further, the building line shall be at least 3m away from the boundary of recreational open space.

5.4.4 Industrial Zones

In the case of sub-division of land in industrial zones of area 0.8 hectare or more, 5 percent of the total area shall be reserved as amenity open space which shall also serve as a general parking space; when such amenity open space exceeds 1500 m², the excess area could be utilized for the construction of buildings for banks, canteens, welfare centres and such other common purposes considered necessary for the industrial user, as approved by the Authority.

5.4.4.1 In all industrial plots measuring 100 m² or more in area, 10 percent of the total area shall be provided as an amenity open space to a maximum of 2500 m². Such an amenity open space shall have a means of access and shall be so located that it could be conveniently utilized as such by the persons working in the industry.

5.4.5 Other Amenities

In addition to community open/social spaces, the layouts shall provide for the following, depending on the magnitude of the settlement and as decided by the Authority.

a) Educational Facilities - Nursery school, primary school, middle school, high school or college as applicable.

b) Health facility - Clinic, health centre, dispensary or hospital, as applicable.

c) Commercial facility (including shopping facility) – Booth(kiosk/container), shops, convenience shopping centre, local shopping centre, or zonal shopping centre, as applicable.

d) Communication facilities and essential services – Post office, post and telegraph, police post, police station, fire station.

e) Social, community and cultural facilities - Religious building, community hall, welfare centre, cinema.

Note: The requirements of essential amenities for low income housing shall be given in Appendix D.

5.4.6 Every layout or subdivision shall take into account the provisions of development plan and if the land is affected by any reservation for public purposes, the Authority may agree to adjust the location of such reservations to suit the development.

5.5 REQUIREMENTS OF PLOTS

5.5.1 No building shall be constructed on any site, on any part of which there is deposited
refuse, excreta or other offensive matter objectionable to the Authority, until such refuse has been removed there from and the site has been prepared or left in a manner suitable for building purposes to the satisfaction of the Authority.

5.5.2 Damp Sites
Wherever the dampness of a site or the nature of the soil renders such precautions necessary, the ground surface of the site between the walls of any building erected thereon shall be rendered damp-proof to the satisfaction of the Authority.

5.5.3 Surface Water Drains
Any land passage or other area within the curtilage of a building shall, if the Authority so requires, be effectively drained by surface water drains or other means.

5.5.3.1 The written approval of the Authority shall be obtained for connecting any subsoil or surface water drain to a sewer.

5.5.4 Underground cisterns for water storage
The provision of underground cisterns for water storage in public and private buildings shall be encouraged.

5.5.5 Distance from Electric Lines
No verandah, balcony, or the like shall be allowed to be erected or re-erected or any additions or alterations made to a building within the distances quoted below in accordance with the current Ghana Electricity Rules and its amendments from time to time between the building and any overhead electric supply line.

<table>
<thead>
<tr>
<th>Vertically</th>
<th>Horizontally</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>m</td>
</tr>
</tbody>
</table>

a) Low and medium

<table>
<thead>
<tr>
<th>Voltage lines and service lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>1.2</td>
</tr>
</tbody>
</table>

b) High voltage lines up to and including 11000 V

<table>
<thead>
<tr>
<th>Voltage lines and service lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7</td>
</tr>
<tr>
<td>1.2</td>
</tr>
</tbody>
</table>

c) High voltage lines above 11000V and up to and including 33000 V

<table>
<thead>
<tr>
<th>Voltage lines and service lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7</td>
</tr>
<tr>
<td>2.0</td>
</tr>
</tbody>
</table>

d) Extra high voltage lines beyond 33000 V

<table>
<thead>
<tr>
<th>Voltage lines and service lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.7</td>
</tr>
<tr>
<td>2.0</td>
</tr>
</tbody>
</table>

(Plus 0.3m for every part thereof)
(plus 0.3m for every part thereof)

5.5.6 Distance of site from the normal edge of water course/area may be specified by the Authority, keeping in view the normal maximum flood/tide level.

5.5.7 Size of Plots
5.5.7.1 Residential
Each plot shall have a minimum size/frontage corresponding to the type of development as given below:

<table>
<thead>
<tr>
<th>Type of Development</th>
<th>Plot Size m²</th>
<th>Frontage M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached building</td>
<td>Above 250</td>
<td>Not Below 6</td>
</tr>
<tr>
<td>Semi-detached building</td>
<td>125 – 250</td>
<td>Not Below 4.5</td>
</tr>
<tr>
<td>Row type building</td>
<td>50 – 125</td>
<td>Not Below 4.5</td>
</tr>
</tbody>
</table>

Note – For low income housing see Appendix D.
5.5.7.1.1 The minimum size of the site for group housing development shall be as given in the Master Plan and local development control rules.

5.5.7.2 Industrial
The size of the plot shall not be less than 300 m² and its width shall not be less than 15 m.

5.5.7.3 Other Land uses
The minimum size of plots for buildings for other uses like business, educational, mercantile, assembly (cinema theatre), petrol filling station, etc. shall be as decided by the Authority subject to 5.5.7.3.1.

5.5.7.3.1 Assembly Halls/Cinema Theatres
The minimum size of plot for assembly buildings/cinema theatres used for public entertainment and religious/social centres, with fixed seats shall be on the basis of seating capacity of the building at the rate of 1 m² per seat.

5.5.7.3.2 Fuel/Gas filling Station
The size of the plot shall not be less than:

- a) 31 x 17m in the case of petrol filling station with kiosk without service bay, and 37 x 31 m in the case of petrol filling station with service bay.

5.6 OPEN SPACES (WITHIN A PLOT)

5.6.1 General
Every room intended for human habitation shall abut on an interior or exterior open space or an open verandah, open to such interior or exterior open space.

5.6.1.1 The open spaces inside and around a building have essentially to cater for the lighting and ventilation requirements of the rooms abutting such open spaces, and in the case of buildings abutting on streets in the front, rear or sides, the open spaces provided shall be sufficient for the future widening of such streets.

5.6.1.2 Open spaces separate for each building of wing –
The open spaces shall be separate or distinct for each building and where a building has two or more wings, each wing shall have separate or distinct open spaces for the purposes of lighting and ventilation of the wings. However, separation between accessory and main buildings more than 7m in height shall not be less than 1.5m; for buildings up to 7m in height, no such separation shall be required.

5.6.2 Residential Buildings

5.6.2.1 Exterior open Spaces

5.6.2.1.1 Front Open Space
a) Every building fronting a street shall have a front space, forming an integral part of the site as below:

| Front open space, Minimum Width of street Fronting the plot (M) (m) |
|-------------------------|-----------------|
| 1.5*                   | Up to 7.5*      |
| 3.0                    | 7.5 to 18       |
| 4.5                    | 18 to 30        |
| 6.0                    | Above 30        |

* For buildings up to a maximum height 7m.

Note – In case a building abuts two or more streets, the value of open spaces is to be based on the average width of streets,
subject to a minimum of 1.8m for cases (ii), (iii) and (iv) of Table 4.1, above.

b) For streets less than 7.5m in width, the distance of the building (building line) shall be at least 5m from the centre line of the street See 5.3.3.5.

Note – This limiting distance has to be determined by the Authority for individual road/street widths taking into account the traffic flow.

5.6.2.1.2 Rear Open Space

a) Every residential building shall have a rear open space, forming an integral part of the site, of an average width of 3m and at no place measuring less than 1.8m, except that in the case of a back-to-back-site, the width of the rear open space shall be 3m throughout. Subject to the condition of free ventilation, the open space left up to half the width of the plot shall also be taken into account for calculating the average width of the rear open space. For plots of depth less than 9m, for buildings up to 7m in height, the rear open space may be reduced to 1.5m.

b) Rear Open Space to Extend Throughout the Rear Wall – The rear open space shall be co-extensive with the entire face of the rear wall. If a building abuts on two or more streets, such rear open space shall be provided throughout the face of the rear wall. Such rear wall shall be the wall on the opposite side of the face of the building abutting on the wider street unless the Authority directs otherwise.

5.6.2.1.3 Side Open Space

a) Every semi-detached and detached building shall have a permanently open air space, forming an integral part of the site as below:

(i) For detached buildings there shall be a minimum side open space of 3m on both the sides.

NOTE: For detached residential buildings up to 7m in height on plots with a frontage less than 12m, one of the side open spaces may be reduced to 1.5m.

(iii) For row-type buildings, no side open is required.

(b) In the case of semi-detached buildings, the open spaces provided on one side shall be as in Clause 5.6.2.1.3 and all habitable rooms shall abut either on this side open space or front and rear open spaces or an interior open space Clause 5.6.2.5.

5.6.2.2 The provisions of Clause 5.6.2.1.2 and 5.6.2.1.3 are not applicable to parking lock-up garages up to 3m in height located at a distance of 7.5m from any street line or front boundary of the plot.

5.6.2.3 The open spaces mentioned in Clause 5.6.2.1.1 to 5.6.2.1.3 shall be for residential buildings up to a height of 10m.

5.6.2.3.1 For buildings of height above 10m, the open spaces (side and rear) shall be as given in Table 5.2. The front open spaces for increasing heights of buildings shall be governed by 6.5.4.1(a).

TABLE 5.2 - Side and Rear Open Spaces for different Heights of Buildings

<table>
<thead>
<tr>
<th>Height of buildings</th>
<th>Side and rear open spaces to be left around building</th>
<th>m</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ii)</td>
<td>15</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>18</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>iv)</td>
<td>21</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>24</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>vi)</td>
<td>27</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>vii)</td>
<td>30</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>viii)</td>
<td>35</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>ix)</td>
<td>40</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Note 1 – For buildings above 24m in height, there shall be a minimum front open space of 6m.

Note 2 – Where rooms do not derive light and ventilation from the exterior open space, the width of such exterior open space as given in Col. 3 may be reduced by 1m subject to a minimum of 3m and a maximum of 8m. No further projections shall be permitted.

Note 3 – If the length or depth of the building exceeds 40m, add to Col. 3 ten percent of length or depth of building minus 4.0m.

5.6.2.3.2 For tower-like structures, as an alternative to 5.6.2.3., open spaces shall be as below:

a) up to a height of 24m, with one set-back, the open spaces at the ground level, shall be not less than 6m;

b) for heights between 24m and 37.5m with one set-back, the open spaces at the ground level, shall be not less than 9m;

c) for heights above 37.5m with two set-backs, the open spaces at the ground level, shall be not less than 12m; and

d) the deficiency in the open spaces shall be made good to satisfy 5.6.2.3.1. through the set-backs at the upper levels; these set-backs shall not be accessible from individual rooms/flats at these levels.

5.6.2.4 The front open space would govern the height of the building (see 6.5.4).

5.6.2.5 Interior Open Spaces

a) Inner Courtyard – In case the whole of one side of every room excepting bath, WC and store room is not abutting on either the front, rear or side(s) open spaces, it shall abut on an inner courtyard, whose minimum width shall be 3m.

Further, the inner courtyard shall have an area, throughout its height, of not less than the square of one-fifth the height of the highest wall abutting the courtyard. Provided that when any room (excluding staircase bay, bathroom and water-closet) is dependent for its light and ventilation on an inner courtyard, the dimension shall be such as is required for each wing of the building.

Where only water closet and bath room are abutting on the interior courtyard, the size of the interior courtyard shall be in line with the provision for ventilation shaft as given in Clause 5.6.2.5(b))

b) Ventilation Shaft – For ventilating the spaces for water closets and bath rooms, if not opening on to front, side, rear and interior open spaces, these shall open on to the ventilation shaft, the size of which shall not be less than the values given below:

<table>
<thead>
<tr>
<th>Height of Buildings m</th>
<th>Size of Ventilation Shaft m²</th>
<th>Minimum Size of Shaft m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 10</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>12</td>
<td>2.8</td>
<td>1.2</td>
</tr>
<tr>
<td>18</td>
<td>4.0</td>
<td>1.5</td>
</tr>
<tr>
<td>24</td>
<td>5.4</td>
<td>1.8</td>
</tr>
<tr>
<td>30</td>
<td>8.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Above 30</td>
<td>9.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Note 1 – For buildings of height above 30m, a mechanical ventilation system shall be installed besides the provision of minimum ventilation shaft.

Note 2 – For fully air-conditioned residential buildings for lodging purposes, the ventilation shaft need not be insisted upon, provided the air-conditioning system works in an uninterrupted manner, also, provided there is an alternative source of power supply.

c) Outer Courtyard – The minimum width of the outer courtyard (as distinguished from its depth) shall be not less than 2.4m. If the width of the outer courtyard is less than 2.4m, it shall be treated as a notch and the provisions of outer courtyard shall not apply. However, it the depth of the outer courtyard is more than the width, the provisions of 5.6.1.2 shall apply for the open spaces to be left between the wings.
5.6.2.6 Joint Open Air Space –

Every such interior or exterior open air space, unless the latter is a street, shall be maintained for the benefit of such building exclusively and shall be entirely within the owner’s own premises.

5.6.2.6.1 If such interior or exterior open air space is intended to be used for the benefit of more than one building belonging to the same owner, the width of such open air space shall be the one specified for the tallest building as specified in 5.6.2.3 abutting on such open air space.

5.6.2.6.2 If such interior or exterior open air space is jointly owned by more than one person, its width shall also be as specified in Clause 5.6.2, provided every such person agrees in writing to allow his portion of such joint open air space to be used for the benefit of every building abutting on such joint open air space and provided he sends such written consent to the Authority for record. Such common open air space shall thenceforth be treated as a permanently open air space required for the purposes of the Code. No boundary wall between such joint open air space shall be erected or raised to a height of more than 2.0m.

5.6.3 Other Occupancies

5.6.3.1 Open spaces for other occupancies shall be as below:

a) **Educational Buildings** – Except for nursery schools, the open spaces around the building shall be not less than 6m;

b) **Institutional Buildings** – The open spaces around the building shall be not less than 6m; and

c) **Assembly Buildings** – The open space at front shall be not less than 12m and the other open spaces around the building shall be not less than 6m.

Note – However, if assembly buildings are permitted in purely residential zones, the open spaces around the building shall be not less than 12m.

d) **Business, Mercantile and Storage Buildings** – The open spaces around the building shall be not less than 4.5m. Where these occur in a purely residential zone or in a residential with shops line zone, the open spaces may be relaxed.

e) **Industrial Buildings** – The open spaces around the building shall be not less than 4.5m for heights up to 16m, with an increase of the open spaces of 0.25m for every increase of 1m or fraction thereof in height above 16m.

Note – Special rules for narrow industrial plots in the city, namely plots less than 15m in width, in the city, namely plots less than 15m in width, and with appropriate setbacks from certain streets and highways, shall be applicable.

f) **Hazardous Occupancies** – The open spaces around the building shall be as specified for industrial buildings (see 5.6.2.1(e)).

5.6.4 Exemption to Open Spaces

5.6.4.1 Projections into Open Spaces –

Every open space provided either interior or exterior shall be kept free from any erection thereon and shall be open to the sky, except as below:

a) cornice, roof or weather shade not more than 0.75m wide;

b) sunshades over windows/ventilators or other openings not more than 0.75m wide;

c) canopy at first floor level, but not to be used as a sit out with clearance of 1.5m between the plot boundary and the canopy;

d) projected balcony at higher floors of width not more than 0.9m; and

e) projecting rooms/balconies (see (d) at alternate floors such that rooms of the lower two floors get light and air and the projection being not more than the height of the storey immediately below.
However, these projections into open spaces shall not reduce the minimum required open spaces.

5.6.4.1 Accessory Building

The following accessory buildings may be permitted in the open spaces:

a) In an existing building, sanitary block of 2.4m in height subject to a maximum of 4m² in the rear open space at a distance of 1.5m from the rear boundary may be permitted, where facilities are not adequate.

b) Parking lock up garages not exceeding 2.4m in height shall be permitted in the side or rear open spaces at a distance of 7.5m form any road line or the front boundary of the plot; and

c) Suction tank and pump room each up to 2.5m² in area.

5.6.4.2 Projection into Street

5.6.4.2.1 In existing built-up or congested areas, no projection of any sort whatsoever, except sunshades (see 5.6.4.2.3) extending more than 230mm below a height of 4.3m, shall project over the road or over any drain or over any portion outside the boundaries of the site, provided the projection arising out of the vertical part of the rain-water spouts projecting at the road level or the water pipe may be permitted in accordance with the drainage plan.

5.6.4.2.2 Porticos in Existing Developed Area

Porticos in bazaar/shopping areas of existing developed areas may be permitted to project on road land subject to the following limitations:

a) porticos may be allowed on such roads leaving a minimum clear space of 18m between kerbs;

b) the porticos shall not be less than 3m wide;

c) nothing shall be allowed to be constructed on the portico which shall be constructed on the portico which shall be used as an open terrace;

d) nothing shall be allowed to project beyond the line of arcades; and

e) the space under the portico shall be paved and channeled according to the directions of the Authority.

5.6.4.2.3 Sunshades Over Windows and Ventilators –

Projections of sunshades over windows or ventilators in existing built-up or congested areas when permitted by the Authority shall fulfill the following conditions.

a) no sunshade shall be permitted over the road or over any drain or over any portion outside the boundaries of the site below a height of 2.8m from the road level;

b) sunshades provided above a height of 2.8m from the ground level shall be permitted to project up to a maximum width of 600mm, if the road over which they project exceeds 9m in width; and

c) no sunshade shall be permitted on roads less than 9m in width or on roads having no footpaths.

5.6.5 Limitations to Open Spaces

5.6.5.1 Safeguard Against Reduction of Open Space

No construction work on a building shall be allowed if such work operates to reduce an open air space of any other adjoining building, belonging to the same owner to an extent less than what is prescribed at the time of the proposed work or to reduce further such open space if it is already less than that prescribed.

5.6.5.2 Additions or Extensions to a Building

Additions or extensions to a building shall be allowed, provided the open spaces for the
additions/extensions satisfy 5.6.2 after such additions/extensions are made.

5.7 OFF-STREET PARKING SPACES

5.7.1 The off-street parking (on-site parking) spaces in a plot to be provided shall be in accordance with Appendix B. The spaces given in Appendix B shall be considered by the Authority in conjunction with the Development Rules, in force, if any.

5.8 GREENBELTS AND LANDSCAPING

5.8.1 General

Greenbelts and landscaping including plantation of shrubs and trees help to certain extent in enhancing the environmental quality.

5.8.1.1 Planting of trees in streets and in open spaces should be done carefully to take advantage of both shades and sunshine without handicapping the flow of natural winds. Their advantage for abating glare and for providing cool and/or warm pockets in developed areas should also be taken.

5.8.1.2 Where relief from noise is to be provided by means of greenbelts, these may be of considerable width and be landscaped. The extent of relief that may be derived from the above may be estimated only after considering other environmental factors. Strong leafy trees may be planted to act as noise baffles. Shrubs or creepers may also be planted for additional protection between tree trunks; artificial mounds and banks should be formed wherever practicable.

5.8.2.1 Suitable provisions may be made for greeneries including plantation of shrubs and trees as a part of environmental protection in general. This aspect shall be taken care of from the initial stage of town and country planning, zoning and planning of development of particular area and group housing. Finally, this aspect shall also be taken into account in planning individual building of different occupancies. A guide for the quantum of plantation of shrubs, trees and other greenery in different occupancies and community spaces is given in Appendix C.

5.8.2.2 The types of plants, the distance between tree/plants from the building and the distance between plants shall be carefully worked out keeping in view of the structural safety and aesthetic requirements of buildings.

5.8.3 Trees shall be numbered area-wise, plot-wise and road-wise by the concerned authority and they shall be checked periodically.

5.8.4 Cutting and pruning of trees in public as well as private areas shall be suitably regulated. Trees shall be cut only after obtaining the permission of the Authority designated for this purpose.

APPENDIX B

OFF-STREET PARKING SPACES

B-1 The spaces to be left out for off-street parking as given in B-2 shall be in addition to the open spaces left out for lighting and ventilation purposes as given in Clause 4.14. However, one row of car parking may be provided in the front open space of 12m without reducing the clear vehicular access way to less than 6m.

B-1.1 Further 50 percent of the open spaces required around buildings under 4.8 may be allowed to be utilized for parking or loading or unloading spaces, provided that a minimum distance of 3.6 m around the building shall be kept free from any parking, loading or unloading spaces.

B-2 Each off-street parking space provided for motor vehicles (cars) shall not be less than 13.75 m² in area, and for scooters and cycles the parking spaces provided shall not be less than 1.25m² and 1.00 m² respectively.

B-3 For buildings of different occupancies, off-street parking space for vehicles shall be provided as stipulated below:
a) **Motor Vehicles** – Space shall be provided as specified in Table 4.8 for parking motor vehicles (cars)

b) **Other Types of Vehicles** – For non-residential buildings, in addition to the parking areas provided in (a) above, 25 to 50 percent additional parking space shall be provided for parking other types of vehicles and the additional spaces required for other vehicles shall be as decided by the Authority, keeping in view the nature of traffic generated in the city.

**B-4** Off-street parking space shall be provided with adequate vehicular access to a street; and the area of drives, aisles and such other provisions required for adequate manoeuvering of vehicle shall be exclusive of the parking space stipulated in these rules.

**B-5** If the total parking space required by these rules is provided by a group of property owners for their mutual benefits, such use of this space may be construed as meeting the off-street parking requirements under these rules, subject to the Approval of the Authority.

**B-6** In addition to the parking spaces provided, for buildings of mercantile (commercial), industrial and storage type at the rate of one such space of 3.5 x 7.5m, for loading and unloading activities, for each 1000m² of floor area or fraction thereof, shall be provided.

**B-7** Parking spaces shall be paved and clearly marked for different types of vehicles.

**B-8** In the case of parking spaces provided in basements, at least two ramps of adequate width and slope shall be provided, located preferably at opposite ends.

### Table 4.8 - Off-Street Parking Spaces (Clause B-3 (a))

<table>
<thead>
<tr>
<th>Col. No.</th>
<th>Occupancy</th>
<th>One Car Parking Space for Every</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Population between 200,000 to 1,000,000</td>
</tr>
<tr>
<td>1)</td>
<td>Residential</td>
<td>2 tenements having carpet area 101 to 200 m²</td>
</tr>
<tr>
<td></td>
<td>i) Multi-family</td>
<td>b) 1 tenement exceeding 201 m² carpet area</td>
</tr>
<tr>
<td></td>
<td>ii) Lodging establishments, tourist homes and hotels, with lodging accommodation</td>
<td>4 guest rooms</td>
</tr>
<tr>
<td>2)</td>
<td>Educational ¹</td>
<td>70 m² carpet area or fraction thereof of the administrative office area and public service areas</td>
</tr>
<tr>
<td>3)</td>
<td>Institutional (Medical)</td>
<td>10 beds (Private)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 beds (Public)</td>
</tr>
</tbody>
</table>
APPENDIX C
GUIDE FOR PLANTATION OF SHRUBS, TREES AND GREENERY

C-1 The norms for plantation of shrubs, trees and other greeneries for residential, educational, institutional and industrial occupancies shall be as follows:

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Plot Size ( \text{mm}^2 )</th>
<th>Greenery to be Planted, Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Residential</td>
<td>For smaller plots (smaller than 200 ( \text{m}^2 )), EWS housing, slum areas and the like</td>
<td>For every 50 families create one small community space of about 100 ( \text{m}^2 ) where clumps of trees may be planted so as to provide shade and improve the quality of environment</td>
</tr>
<tr>
<td></td>
<td>200 and above</td>
<td>i) 10 percent of open space to be left unpaved for greenery with at least two small/medium trees up to plot area of 500 ( \text{m}^2 ) ii) An additional one tree for every 100 ( \text{m}^2 ) area of plot or part thereof above 500 ( \text{m}^2 ).</td>
</tr>
</tbody>
</table>
### C-2
For other occupancies namely assembly, business, mercantile, the quantum of greenery shall be planned taking the development as a whole. However, a minimum of 50 trees shall be provided per hectare; 25 percent of the permissible open space to be covered by greenery such as shrubs, grass, and suitably landscaped.

### C-3 COMMUNITY SPACES

#### C-3.1 Community Open Spaces – The open spaces to be left in the total development of the area are covered in 5.4. These open spaces should be suitably landscaped. A minimum of 125 trees per hectare shall be provided.

#### C-3.2 Roads in a Development Plan –
Trees shall be provided on either side of the road or on both sides depending upon the width of the roads, the location of building along the road side and other considerations. However, minimum one tree for every 10m shall be provided.

### APPENDIX D

#### D-1 GENERAL

**D-1.1** These requirements cover the planning and general building requirements of low income housing developed as clusters (Table 4.9). The requirements regarding layout planning of low income housing clusters are applicable to public agencies (government bodies). The requirements on design and construction of buildings for low income housing in approved layouts are applicable to public agencies/government bodies or private builders.

**D-1.2** In these planning standards, the general plan requirement for community open spaces estimated at 0.3 ha for thousand persons is provided; road areas are worked out between 10 and 20 percent of the site area; one nursery school of 0.1 ha is provided for a population of 1500 and shopping centres at 4 shops per thousand populations are also covered. It would, therefore, be seen that even for apparently high densities, the basic

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Minimum Land Area</th>
<th>Trees Required</th>
<th>Open Space Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Educational and Institutional</td>
<td>300 – 1000</td>
<td>i) 125 trees per hectare</td>
<td>ii) 50 percent of the permissible open space for greenery</td>
</tr>
<tr>
<td>c) Industrial</td>
<td>Above 1000</td>
<td>i) 150 trees per hectare</td>
<td>ii) 40 percent of the permissible open space to be covered by greenery</td>
</tr>
</tbody>
</table>

Note – Landscape proposal shall be got approved from the Local Authority along with the building plan for group housing schemes.

Note 1 – For industrial plots, it is advisable to have peripheral plantation to minimize pollution especially air and noise pollution.

Note 2 – Large polluting industry should be separated from the neighbouring residential area by a thick green belt which should occupy an area of about 15 percent of the industrial area.

Note 3 – Landscape proposal shall be got approved from the local Authority along with the building plan.
requirements and community facilities are also taken care of.

D-1.3 It is emphasized that this type of development should apply to clusters of 400 dwelling units, so distributed in the development under consideration as to maintain the overall densities of the master plan for the area (see Note 1 of Table 5.9).

Table 5.9 - Maximum Densities for Low Income Housing

<table>
<thead>
<tr>
<th>Col.</th>
<th>Density in Dwelling Units/Ha for No. of Storeys</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plinth area of unit of 20 m² 30 m²</td>
</tr>
<tr>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>130 85</td>
</tr>
<tr>
<td>ii)</td>
<td>250 170</td>
</tr>
<tr>
<td>iii)</td>
<td>300 225</td>
</tr>
<tr>
<td>iv)</td>
<td>350 260</td>
</tr>
<tr>
<td>v)</td>
<td>400 300</td>
</tr>
</tbody>
</table>

Note 1 – These densities are applicable to a cluster of dwelling up to 400, with a family of 5 members.

Note 2 – Vertical incremental housing shall be permitted in single ownership plot.

Note 3 – These densities include provision for open spaces, convenience-shopping, nursery, and all internal roads and pathways, but do not include peripheral road around the cluster.

Note 4 – The minimum density shall be 75 percent of the above.

D-2 PLANNING

D-2.1 Type of Development – The type of development for low income housing shall be plotted development as row housing/flatted development as row housing/block development as group housing.

D-2.2 Density – The maximum density, in dwelling units/hectare, shall be as given in Table 4.9.

D-2.3 Size of Plot/Plinth Area – The minimum plot size shall be as follows, with coverage not exceeding 75 percent.

<table>
<thead>
<tr>
<th>Minimum plot size</th>
<th>Type of Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 m²</td>
<td>Incremental housing with one room, cooking space and combined bath and WC on ground floor and future extension of one room and a bath on the first floor/ground floor</td>
</tr>
<tr>
<td>40 m²</td>
<td>Two roomed house on each floor for group housing/individual ownership house</td>
</tr>
</tbody>
</table>

Note 1 – The minimum size of plots takes into account the need of incremental housing. In the case of cities (other than metropolitan cities) with population less than 0.5 million, the size of the plots may be increased by 33 1/3 percent

Note 2 – In exceptional cases in metropolitan cities with population more than 1 million, the size of plots may be brought down to 25m² in the cases of low income house colonies located in congested areas or in areas as decided by the Authority.

D-2.3.1 Minimum Frontage –

The minimum frontage of the plot shall be 3.6m in width.

Note - The minimum frontage of 3.6m is desirable. For an economical layout, group housing appears to be a good solution. But if plotted development is to be adopted and if there are occasions when sufficient frontage is not available, the same may be reduced to 3m.

D-2.4 Height of Building –

The height of building shall not exceed 15m.

Note - For buildings up to the height of 15m, there is no need to provide lifts.
D-5 Other Requirements (to be edited)

D-5.1 One water tap per dwelling unit may be provided, where adequate drinking water supply is available. If supply is inadequate, public hydrants shall be provided. In the absence of piped water supply, it could be done through hand pumps.

D-5.2 The infrastructural services shall be provided before the plots are handed over to individual owners.

D-6 Site and Services Schemes (to be edited)

D-6.1 The developed plot sizes shall be as per D-2.3. Services would have to be laid by the Agency concerned as per the provisions of the Code. In so far as roads and pathways are concerned, they could also be in line with D-4.

D-6.2 Site and services schemes shall provide for the following:

a) the infrastructural needs for a permanent housing, depending upon requirements;

5.10 PRESERVATION OF NATURAL RESOURCES

5.10.1 Protection by area.

Where flood hazard areas, surface water bodies or wetlands, conservation areas, parklands, agricultural lands or greenfields are located on, or adjacent to, a plot, the development of the plot as a building site shall comply with the provisions of Clauses 5.10.2 through 5.10.7.

5.10.2. Flood hazard areas.

For locations within flood hazard areas, unless compliance with Clause 5.10.2.1 or Clause 5.10.2.2 is required by this Code new buildings and structures and substantial improvements shall comply with Clause 5.10.2.3.

5.10.2.1 Flood hazard area preservation, general.

Where this Clause is indicated to be applicable in this Code new buildings and structures, site disturbance, and development of land shall be prohibited within flood hazard areas.

5.10.2.2 Flood hazard area preservation, specific.

Where this Clause is indicated to be applicable in this Code new buildings and structures, site disturbance, and development of land shall be prohibited within the specific flood hazard areas established pursuant to local land use authority.

5.10.2.3 Development in flood hazard areas.

New buildings, structures and substantial improvements constructed in flood hazard areas shall be in compliance with this Code provided the lowest floors are elevated or dry floodproofed to not less than 25 mm (1 foot) above the elevation required by this Code, or the elevation established by the jurisdiction, whichever is higher.

5.10.3 Surface water protection.

Where this Clause is indicated to be applicable in this Code buildings and building site improvements shall not be located over, or
located within a buffer as established by the jurisdiction, around or adjacent to oceans, lakes, rivers, streams and other bodies of water that support or could support fish, recreation or industrial use. The buffer shall be measured from the ordinary high-water mark of the body of water.

Exceptions:

1. Buildings and associated site improvements specifically related to the use of the water including, but not limited to, piers, docks, fish hatcheries, and habitat restoration facilities, shall be permitted where the impacts of the construction and location adjacent to or over the water on the habitat is mitigated.

2. Buildings and associated site improvements shall be permitted where a wetlands permit has been issued under a national wetlands permitting program or otherwise issued by the authority having jurisdiction.

5.10.4 Wetland protection.
Buildings and building site improvements shall not be located within a wetland or within a buffer as established by the jurisdiction around a wetland.

Exception: Buildings and associated site improvements specifically related to the use of the wetland including, but not limited to, piers, docks, fish hatcheries, and habitat restoration facilities, shall be permitted where the impacts of the construction and location adjacent to or over the wetland on the habitat are mitigated.

5.10.5 Conservation area.
Where this Clause is indicated to be applicable in this Code site disturbance or development of land in or within 15240 mm (50 feet) of a designated conservation area shall not be permitted.

Exception: Buildings and associated site improvements located in or within 15240 mm (50 feet) of a conservation area shall be permitted where the building and associated site improvements serve a purpose related to the conservation area as determined by the authority that designated the conservation area.

5.10.6 Agricultural land.
Where this Clause is indicated to be applicable in this Code buildings and associated site improvements shall not be located on land zoned for agricultural purposes.

Exception: Buildings and associated site improvements shall be permitted to be located on agriculturally zoned land where the building serves an agriculturally related purpose, including, but not limited to, primary residence, farmhouse, migrant workers housing, farm produce storage, processing and shipping.

5.10.7 Greenfield sites.
Where this Clause is indicated to be applicable in this Code site disturbance or development shall not be permitted on greenfield sites.

Exception: The development of new buildings and associated site improvements shall be permitted on greenfield sites where the jurisdiction determines that adequate infrastructure exists, or will be provided, and where the sites comply with not less than one of the following:

1. The greenfield site is located within 0.4 km (1/4 mile) of developed residential land with an average density of not less than 8 dwelling units per acre (19.8 dwelling units per hectare).

2. The greenfield site is located within 0.8 km (1/2 mile) walking distance of not less than 7 diverse uses. The diverse uses shall include not less than one use from each of the following categories of diverse uses: retail, service, or community facility.

3. The greenfield site has access to transit service. The building on the building site shall be located in compliance with one of the following:

3.1. Within 0.4 km (1/4 mile) distance, measured over roads or designated walking surfaces, of not less than 5 diverse uses and within 0.8 km (1/2 mile) walking distance of not less than 7 diverse uses.
planned bus or streetcar stops.

3.2. Within 0.8 km \(\frac{1}{2}\) mile distance, measured over designated walking surfaces, of existing or planned rapid transit stops, light or heavy passenger rail stations, ferry terminals, or tram terminals.

4. The greenfield site is located adjacent to areas of existing development that have connectivity of not less than 35 interClauses per square kilometer (90 interClauses per square mile). Not less than 25 percent of the perimeter of the building site shall adjoin, or be directly across a street, public bikeway or pedestrian pathway from the qualifying area of existing development.

4.1. InterClauses included for determination of connectivity shall include the following:

4.1.1. InterClauses of public streets with other public streets;

4.1.2. InterClauses of public streets with bikeways and pedestrian pathways that are not part of a public street for motor vehicles; and

4.1.3. InterClauses of bikeways and pedestrian pathways that are not part of a public street for motor vehicles with other bikeways and pedestrian pathways that are not part of a public street for motor vehicles.

4.2. The following areas need not be included in the determination of connectivity:

4.2.1. Water bodies, including, but not limited to lakes and wetlands.

4.2.2. Parks larger than \(\frac{1}{2}\) acre \(2023 \text{ m}^2\), designated conservation areas and areas preserved from development by the jurisdiction or by the state or federal government.

4.2.3. Large facilities including, but not limited to airports, railroad yards, college and university campuses.

5.10.7.1 Site disturbance limits on greenfield sites.

For greenfield sites that are permitted to be developed, site disturbances shall be limited to the following areas:

1. Within 18 288 mm (40 feet) of the perimeter of the building;

2. Within 4572 mm (15 feet) of proposed surface walkways, roads, paved areas and utilities;

2. Within 7620 mm (25 feet) of constructed areas with permeable surfaces that require additional staging areas to limit compaction in the constructed areas.

5.11 STORMWATER MANAGEMENT

5.11.1 Stormwater management.

Stormwater management systems, including, but not limited to, infiltration, evapo-transpiration; rainwater harvest and runoff reuse; shall be provided and maintained on the building site.

5.11.1.1 Increased runoff.

Stormwater management systems shall address the increase in runoff that would occur resulting from development on the building site and shall either:

1. Manage rainfall onsite and size the management system to retain not less than the volume of a single storm that is equal to the 95th-percentile rainfall event as recorded by the National Climatic Data Center or other approved precipitation records and all smaller storms and maintain the predevelopment natural runoff; or

2. Maintain or restore the predevelopment stable, natural runoff hydrology of the site throughout the development or redevelopment process.
Postconstruction runoff rate, volume, and duration shall not exceed predevelopment rates. The stormwater management system design shall be based, in part, on a hydrologic analysis of the building site.

5.11.1.2 Adjoining plots and property.
The stormwater management system shall not redirect or concentrate off-site discharge that would cause increased erosion or other drainage related damage to adjoining plots or public property.

5.11.1.3 Brownfields.
Stormwater management systems on areas of brownfields where contamination is left in place shall not use infiltration. Stormwater management systems shall not penetrate, damage, or otherwise compromise remediation actions at the building site.

5.11.2 Coal tar sealants.
Coal tar sealants shall not be used in any application exposed to stormwater, wash waters, condensates, or any source of water that could convey coal tar sealants into soils, surface waters or groundwaters.

5.12 LANDSCAPE IRRIGATION AND OUTDOOR FOUNTAINS

5.12.1 Landscape irrigation systems.
Irrigation of exterior landscaping shall comply with Clauses 5.12.1.1 and 5.12.1.2.

5.12.1.1 Water for outdoor landscape irrigation.
Outdoor landscape irrigation systems shall be designed and installed to reduce potable water use by 50 percent from a calculated mid-summer baseline in accordance with Clause 5.12.1.2 or, where permitted by State regulation or local ordinances, the system shall be supplied by municipal reclaimed water or with alternate onsite nonpotable water complying with this Code.

    Exceptions: Potable water is permitted to be used as follows:

1. During the establishment phase of newly planted landscaping.
2. To irrigate food production.
3. To supplement nonpotable water irrigation of shade trees provided in accordance with Clause 5.16.2.3.
4. Potable water is permitted for landscape irrigation where approved by local ordinance or regulation.

5.12.1.2 Irrigation system design and installation.
Where in-ground irrigation systems are provided, the systems shall comply with all of the following:

1. The design and installation of outdoor irrigation systems shall be under the supervision of an irrigation professional accredited or certified by an appropriate local or national body.
2. Landscape irrigation systems shall not direct water onto building exterior surfaces, foundations, exterior paved surfaces or adjoining plots. Systems shall not generate runoff.
3. Where an irrigation control system is used, the system shall be one that regulates irrigation based on weather, climatological or soil moisture status data. The controller shall have integrated or separate sensors to suspend irrigation events during rainfall.
4. Irrigation zones shall be based on plant water needs with plants of similar need grouped together. Turfgrass shall not be grouped with other plantings on the same zone.
5. Microirrigation zones shall be equipped with pressure regulators that ensure zone pressure is not greater than 275.8 kPa (40 psi), filters, and flush end assemblies.
6. Irrigation sprinklers shall:

    6.1. Have nozzles with matched precipitation rates.
6.2. Be prohibited on landscape areas less than 1230 mm (4 feet) in any dimension.

6.3. Be prohibited on slopes greater than 1-unit vertical to 4 units horizontal (25-percent slope).

**Exception:** Where the application rate of the irrigation sprinklers is less than or equal to 12.7 mm (0.5 inches) per hour.

6.4. Be permitted for use on turfgrass and crop areas only excepting microsprays of a flow less than 45 gallons (170 liters) per hour.

6.5. If of the pop-up configuration, pop-up to a height of not less than 4 inches (101 mm).

6.6. Only be installed in zones composed exclusively of irrigation sprinklers and shall be designed to achieve a lower quarter distribution uniformity of not less than 0.65.

5.12.2 Outdoor ornamental fountains and water features.

Where available and approved for use by the authority having jurisdiction, alternate nonpotable onsite water sources complying with this Code shall be used for outdoor ornamental fountains and other water features constructed or installed on a building site. Where the fountain or water feature is the primary user of the building site's nonpotable water source, a potable makeup water connection is prohibited.

**Exception:** Outdoor ornamental fountains and water features are allowed to use potable water provided water is recirculated and there is not an automatic refill valve connection to a source of potable water, and provided that either:

1. The catch basin or reservoir is no greater than 379 L (100 gallons); or

2. Less than 1.86 m$^2$ (20 square feet) of water surface area is exposed.

5.12.2.1 Treatment.
The treatment required to maintain appropriate water quality shall be determined by the authority having jurisdiction.

5.12.2.2 Recirculation.
Outdoor ornamental fountains and water features shall be equipped to recirculate and reuse the supplied water.

5.12.2.3 Signage.
Signage in accordance with this Code shall be posted at each outdoor ornamental fountain and water feature where nonpotable water is used.

5.13 MANAGEMENT OF VEGETATION, SOILS AND EROSION CONTROL

5.13.1 Soil and water quality protection.
Soil and water quality shall be protected in accordance with Clause 5.13.1.1 through 5.13.1.6

5.13.1.1 Soil and water quality protection plan.
A soil and water quality protection plan shall be submitted by the owner or the owner's authorized agent and approved prior to construction. The protection plan shall address the following:

1. A soils map, site plan, or grading plan that indicates designated soil management areas for all site soils, including, but not limited to:
   1.1. Soils that will be retained in place and designated as vegetation and soil protection areas (VSPAs).
   1.2. Topsoils that will be stockpiled for future reuse and the locations for the stockpiles.
   1.3. Soils that will be disturbed during construction and plans to restore disturbed soils and underlying subsoils to soil reference conditions.
   1.4. Soils that will be restored and re-vegetated.
   1.5. Locations for all laydown and storage areas, parking areas, haul roads and construction vehicle access,
1. For temporary utilities and construction trailer locations.

1.6. Treatment details for each zone of soil that will be restored, including the type, source and expected volume of materials, including compost amendments, mulch and topsoil.

1.7. A narrative of the measures to be taken to ensure that areas not to be disturbed and areas of restored soils are protected from compaction by vehicle traffic or storage, erosion, and contamination until project completion.

2. A written erosion, sedimentation and pollutant control program for construction activities associated with the project. The program shall describe the best management practices (BMPs) to be employed including how the BMPs accomplish the following objectives:

2.1. Prevent loss of soil during construction due to stormwater runoff or wind erosion, including the protection of topsoil by stockpiling for reuse.

2.2. Prevent sedimentation of stormwater conveyances or receiving waters or other public infrastructure.

2.3. Prevent polluting the air with dust and particulate matter.

2.4. Prevent runoff and infiltration of other pollutants from construction site, including, but not limited to thermal pollution, concrete wash, fuels, solvents, hazardous chemical runoff, pH and pavement sealants. Ensure proper disposal of pollutants.

2.5. Protect from construction activities the designated vegetation and soil protection areas, flood hazard areas and other areas of vegetation that will remain on site.

3. A written periodic maintenance protocol for landscaping and stormwater management systems, including, but not limited to:

3.1. A schedule for periodic watering of new planting that reflects different water needs during the establishment phase of new plantings as well as after establishment. Where development of the building site changed the amount of water reaching the preserved natural resource areas, include appropriate measures for maintaining the natural areas.

3.2. A schedule for the use of fertilizers appropriate to the plants species, local climate and the preestablishment and post-establishment needs of the installed landscaping. Nonorganic fertilizers shall be discontinued following plant establishment.

3.3. A requirement for a visual inspection of the site after major precipitation events to evaluate systems performance and site impacts.

3.4. A schedule of maintenance activities of the stormwater management system including, but not limited to, cleaning of gutters, downspouts, inlets and outlets, removal of sediments from pretreatment sedimentation pits and wet detention ponds, vacuum sweeping followed by high-pressure hosing at porous pavement and removal of litter and debris.
3.5. A schedule of maintenance activities for landscaped areas including, but not limited to, the removal of dead or unhealthy vegetation; reseeding of turf areas; mowing of grass to a height that optimizes lawn health and retention of precipitation.

5.13.1.2 Topsoil protection.

Topsoil that could potentially be damaged by construction activities or equipment shall be removed from areas to be disturbed and stockpiled on the building site for future reuse on the building site or other approved location. Topsoil stockpiles shall be secured and protected throughout the project with temporary or permanent soil stabilization measures to prevent erosion or compaction.

### TABLE 5.13.1.2
MAXIMUM CONE PENETROMETER READINGS

<table>
<thead>
<tr>
<th>SURFACE RESISTANCE (PSI)</th>
<th>SUBSURFACE RESISTANCE (PSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Textures</td>
<td>Sand (includes loamy sand, sandy loam, sandy clay loam, and sandy clay)</td>
</tr>
<tr>
<td>110</td>
<td>260</td>
</tr>
</tbody>
</table>

5.13.1.3 Imported soils.

Topsoils or soil blends imported to a building site to serve as topsoil shall not be mined from the following locations:

1. Sites that are prime farmland, unique farmland, or farmland of statewide importance.
2. Greenfield sites where development is prohibited by Clause 5.10.7.

**Exception:** Soils shall be permitted to be imported from the locations in Items 1 and 2 where those soils are a byproduct of a building and building site development process provided that imported soils are reused for functions comparable to their original function.

5.13.1.4 Soil reuse and restoration.

Soils that are being placed on a building site shall be prepared and placed in a manner that establishes the ability of the soil to support the vegetation that has been retained and that will be planted. Soil reuse and restoration shall be in accordance with Clauses Clause 5.13.1.4.1 and 5.13.1.4.2

#### 5.13.1.4.1 Preparation.

Before placing stockpiled or imported topsoil, compliance with all of the following shall occur:

1. Areas shall be cleared of debris including, but not limited to, building materials, plaster, paints, road base type materials, petroleum based chemicals, and other harmful materials;
2. Areas of construction-compacted subsoil shall be scarified; and
3. The first lift of replaced soil shall be mixed into this scarification zone to improve the transition between the subsoil and overlying soil horizons.

**Exception:** Scarification is prohibited in the following locations:

1. Where scarification would damage existing tree roots.
2. On inaccessible slopes.
3. On or adjacent to trenching and drainage installations.
4. On areas intended by the design to be compacted such as abutments, footings, inslopes.
5. Brownfields.
6. Other locations where scarification would damage...
5.13.1.4.2 Restoration.
Soils disturbed during construction shall be restored in areas that will not be covered by buildings, structures or hardscapes. Soil restoration shall comply with the following:

1. Organic matter. To provide appropriate organic matter for plant growth and for water storage and infiltration, soils shall be amended with a mature, stable compost material so that not less than the top 305 mm (12 inches) of soil contains not less than 3 percent organic matter. Sphagnum peat or organic amendments that contain sphagnum peat shall not be used. Soil organic matter shall be determined in accordance with ASTM D2974. Organic materials selected for onsite amendment or for blending of imported soils shall be renewable within a 50-year cycle.

Exception: Where the reference soil for a building site has an organic level depth other than 305 mm (12 inches), soils shall be amended to organic matter levels and organic matter depth that are comparable to the site’s reference soil.

2. Additional soil restoration criteria. In addition to compliance with Item 1, soil restoration shall comply with not less than three of the following criteria:

2.1. Compaction. Bulk densities within the root zone shall not exceed the densities specified in Table 5.13.1.2 and shall be measured using a soil cone penetrometer in accordance with this Code. The root zone shall be not less than 305 mm (12 inches) nor less than the site’s reference soil, whichever results in the greater depth of measurement. Data derived from a soil cone penetrometer shall be reported in accordance with this Code.

2.2. Infiltration rates. Infiltration rates or saturated hydraulic conductivity of the restored soils shall be comparable to the site's reference soil. Infiltration rates shall be determined in accordance with ASTM D3385 or ASTM D5093. For sloped areas where the methods provided in the referenced standards cannot be used successfully, alternate methods approved by the Code official shall be permitted provided that the same method is used to test both reference soil and onsite soil.

2.3. Soil biological function. Where remediated soils are used, the biological function of the soils' mineralizable nitrogen shall be permitted as a proxy assessment of biological activity.

2.4. Soil chemical characteristics. Soil chemical characteristics appropriate for plant growth shall be restored. The pH, cation exchange capacity and nutrient profiles of the original undisturbed soil or the site’s reference soil shall be matched in restored soils. Salinity suitable for regionally appropriate vegetation shall be established. Soil amendments and fertilizers shall be selected from those that minimize nutrient loading to waterways or groundwater.

5.13.1.5 Engineered growing media.
Where engineered growing media are used onsite, including, but not limited to vegetative roofs, trees located within hardscape areas, and special soils specified for wetlands and environmental restoration sites, such media shall comply with the best available science and practice standards for that engineered growing media and use.

5.13.1.6 Documentation.
The following shall be provided to document compliance with Clauses 5.13.1.3 through 5.13.1.5

1. Documentation, such as receipts from a soil, compost and amendments supplier, to demonstrate that techniques to restore soil occurred; and

2. Soil test results to demonstrate that the selected techniques achieved the criteria of Clause 5.13.1.4.2. Not less than two soil tests shall be conducted on the building site. For building sites where more than 744 $m^2$ (8,000 square feet) of soil is to be disturbed during construction,
there shall be not less than one report for every 372 m² (4,000 square feet) disturbed or report frequency as determined by the registered design professional.

5.13.2 Vegetation and soil protection.

Vegetation and soils shall be protected in accordance with Clauses 5.13.2.1 and 5.13.2.2.

5.13.2.1 Vegetation and soil protection plan.

Where existing soils and vegetation are to be protected, a vegetation and soil protection plan establishing designated vegetation and soil protection areas (VSPAs) shall be submitted with the construction documents and other Submission documents. The protection plan shall address the following:

1. Identification of existing vegetation located on a building site that is to be preserved and protected.

2. Identification of portions of the building site to be designated as vegetation and soil protection areas (VSPAs) that are to be protected during the construction process from being affected by construction activities.

3. Specification of methods to be used such as temporary fencing or other physical barriers to maintain the protection of the designated vegetation and soil protection areas (VSPAs).

4. Specification of protected perimeters around trees and shrubs that are to be included in the designated vegetation and soil protection areas (VSPAs). Perimeters around trees shall be identified as a circle with a radius of not less than 305 mm (1 foot) for every 25 mm (inch) of tree diameter with a radius of not less than 1524 mm (5 feet). The perimeters around shrubs shall be not less than twice the radius of the shrub.

Exception: Approved alternative perimeters appropriate to the location and the species of the trees and shrubs shall be permitted.

5. Specification of methods to protect the viability of the designated vegetation and soil protection areas (VSPAs) to support the remaining vegetation at the conclusion of the construction process including minimizing impacts on the existing stormwater drainage patterns associated with the VSPAs.

6. Identification of plans, methods and practices used to designate essential areas of soil and subsoil disturbance.

5.13.2.1.1 Tree protection zones (TPZ).

Where tree protection zones are specified, the specifications and documentation shall be in accordance with this Code.

5.13.2.2 Invasive plant species.

Invasive plant species shall not be planted on a building site. A management plan for the containment, removal and replacement of any invasive plant species currently on the site shall be generated based on either published recommendation for the referenced invasive plant or guidance prepared by a qualified professional. Existing vegetation that is to be retained on a building site shall be protected as required by Clause 5.13.2.

5.13.3 Native plant landscaping.

Where new landscaping is installed as part of a site plan or within the building site, not less than 75 percent of the newly landscaped area shall be planted with native plant species.

5.14 BUILDING SITE WASTE MANAGEMENT

5.14.1 Building site waste management plan.

A building site waste management plan shall be developed and implemented to divert not less than 75 percent of the land-clearing debris and excavated soils from disposal. Land-clearing debris includes rock, trees, stumps and associated vegetation. The plan shall include provisions that address all of the following:

1. Materials to be diverted from disposal by efficient usage, recycling or reuse on the building site shall be specified.
2. Diverted materials shall not be sent to sites that are agricultural land, flood hazard areas or greenfield sites where development is prohibited by Clause 5.10.1 except where approved by the Code official.

3. The effective destruction and disposal of invasive plant species.

4. Where contaminated soils are removed, the methods of removal and location where the soils are to be treated and disposed.

5. The amount of materials to be diverted shall be specified and shall be calculated by weight or volume, but not both.

6. Where the site is located in a federal or state designated quarantine zone for invasive insect species, building site vegetation management shall comply with the quarantine rules.

7. Receipts or other documentation related to diversion shall be maintained through the course of construction. When requested by the Code official, evidence of diversion shall be provided.

5.14.2 Construction waste.
Construction materials and waste and hardscape materials removed during site preparation shall be managed in accordance with this Code.

5.15 TRANSPORTATION IMPACT

5.15.1 Walkways and bicycle paths.
Not less than one independent, paved walkway or bicycle path suitable for bicycles, strollers, pedestrians, and other forms of nonmotorized locomotion connecting a street or other path to a building entrance shall be provided. Walkways and bicycle paths shall connect to existing paths or sidewalks, and shall be designed to connect to any planned future paths. Paved walkways and bicycle paths shall be designed to minimize stormwater runoff. Pervious and permeable pavement shall be designed in accordance with Clause 5.16.2.4.

5.15.2 Changing and shower facilities.
Buildings with a total building floor area greater than 929 m² (10,000 square feet) and that are required to be provided with long-term bicycle parking and storage in accordance with Clause 5.15.3 shall be provided with onsite changing room and shower facilities. Not less than one shower shall be provided for each 20 long-term bicycle parking spaces, or fraction thereof.

Where more than one changing room and shower facility is required, separate facilities shall be provided for each sex.

5.15.3 Bicycle parking and storage.
Long-term and short-term bicycle parking shall be provided as specified in Table 5.15.3. The required number of spaces shall be determined based on the net floor area of each primary use or occupancy of a building except where Table 5.15.3 specifies otherwise. Accessory occupancy areas shall be included in the calculation of primary occupancy area.

Exceptions:

1. Long-term bicycle parking shall not be required where the total building floor area is less than 232 m² (2,500 square feet).

3. Subject to the approval of the Code official, the number of bicycle parking spaces shall be permitted to be reduced because of building site characteristics including, but not limited to, isolation from other development.
<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>SPECIFIC USE</th>
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<th>LONG-TERM SPACES</th>
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<tr>
<td>A-1</td>
<td>Movie theaters</td>
<td>1 per 50 seats; not less than 4 spaces</td>
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<td>Concert halls, theaters other than for movies</td>
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<td>Restaurants</td>
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<td>Places of worship</td>
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<td>Assembly spaces other than places of worship</td>
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<td>None</td>
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<td>Transit park and ride plots</td>
<td>None</td>
<td>1 per 20 vehicle parking spaces</td>
</tr>
<tr>
<td></td>
<td>Commercial parking facilities</td>
<td>1 per 20 vehicle parking spaces</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>None</td>
<td>2 spaces</td>
</tr>
</tbody>
</table>
Other | Outdoor recreation, parks | 1 per 20 vehicle parking spaces; not less than 2 spaces | None

**NOTE:**

For SI: 1 square foot = 0.0929 m².

a. Requirements based on square feet shall be the net floor area of the occupancy or use.

b. When a calculation results in a fraction of space, the requirements shall be rounded to the next higher whole number.

5.15.3.1 Short-term bicycle parking.
Short-term bicycle parking shall comply with all of the following:

1. It shall be provided with illumination of not less than 11 lux (1 footcandle) at the parking surface;

2. It shall be located at the same grade as the sidewalk or at a location reachable by ramp or accessible route;

3. Horizontal parking spaces shall have a floor area of not less than 457 mm (18 inches) by 1829 mm (72 inches) for each bicycle;

4. Vertical parking spaces shall have a floor area of not less than 457 mm (18 inches) by 1118 mm (44 inches) for each bicycle with not less than 610 mm (24 inches) of clearance above the highest point of the bicycle rack;

5. It shall be provided with a rack or other facility for locking or securing each bicycle;

6. It shall be located within 30 480 mm (100 feet) of, and visible from, the main entrance.

**Exception:** Where directional signage is provided at the main building entrances, short-term bicycle parking shall be permitted to be provided at locations not visible from the main entrance.

5.15.3.2 Long-term bicycle parking.
Long-term bicycle parking shall comply with all of the following:

1. It shall be located on the same building site or within the building;

2. It shall be provided with illumination of not less than 1 footcandle (11 lux) at the parking surface;

3. Horizontal parking spaces shall have a floor area of not less than 18 inches (457 mm) by 72 inches (1829 mm) for each bicycle;

4. Vertical parking spaces shall have a floor area of not less than 18 inches (457 mm) by 44 inches (1118 mm) for each bicycle with not less than 24 inches (610 mm) of clearance above the highest point of the bicycle rack; and

5. It shall be provided with a rack or other facility for locking or securing each bicycle.

Not less than 50 percent of long-term bicycle parking shall be within a building or provided with a permanent cover including, but not limited to, roof overhangs, awnings, or bicycle storage lockers or within covered parking structures.

Vehicle parking spaces, other than those required by Clause 5.15, local zoning requirements and accessible parking required by the In this Code, shall be permitted to be used for the installation of long term bicycle parking spaces.

5.15.7.4 Preferred vehicle parking.

Where either Clause 5.15.4.1 or 5.15.4.2 is indicated to be applicable in this Code, parking provided at a building site shall comply with this Clause. Preferred parking spaces required by this Clause shall be those in the parking facility that are located on the shortest route of travel from the parking facility to a building entrance, but shall not take precedence over parking spaces that are required to be accessible in accordance with the In this Code. Where buildings have multiple entrances with adjacent parking, parking spaces required by this Clause shall be dispersed and located near the entrances. Such parking spaces shall be provided with approved signage that specifies the permitted usage.
5.15.4.1 High-occupancy vehicle parking.

Where employee parking is provided for a building that has a total building floor area greater than 929 m$^2$ (10,000 square feet), a building occupant load greater than 100 and not less than 20 employees, at least 5 percent, but not less than two, of the employee parking spaces provided shall be designated as preferred parking for high-occupancy vehicles.

5.15.4.2 Low-emission, hybrid, and electric vehicle parking.

Where parking is provided for a building that has a total building floor area greater than 929 m$^2$ (10,000 square feet) and that has a building occupant load greater than 100, at least 5 percent, but not less than two, of the parking spaces provided shall be designated as preferred parking for low emission, hybrid, and electric vehicles.

5.16 HEAT ISLAND MITIGATION

5.16.1 General.
The heat island effect of building and building site development shall be mitigated in accordance with Clause 5.16.2 and 5.16.3.

5.16.2 Site hardscape.
In climate zones 1 through 6, as established in this Code, not less than 50 percent of the site hardscape shall be provided with one or any combination of options described in Clauses 5.16.2.1 through 5.16.2.4. For the purposes of this Clause, site hardscape shall not include areas of the site covered by solar photovoltaic arrays or solar thermal collectors.

5.16.2.1 Site hardscape materials.
Hardscape materials shall have an initial solar reflectance value of not less than 0.30 in accordance with ASTM E1918 or ASTM C1549.

Exception: The following materials shall be deemed to comply with this Clause and need not be tested:
1. Pervious and permeable concrete pavements.
2. Concrete paving without added color or stain.

5.16.2.2 Shading by structures.
Where shading is provided by a building or structure or a building element or component, such building, structure, component or element shall comply with all of the following:

1. Where open trellis-type, free-standing structures such as, but not limited to, covered walkways, and trellises or pergolas, are covered with native plantings, the plantings shall be designed to achieve mature coverage within five years;
2. Where roofed structures are used to shade parking, those roofs shall comply with Clause 408.3 in climate zones 1 through 6; and
3. Shade provided onto the hardscape by an adjacent building or structure located on the same plot shall be calculated and credited toward compliance with this Clause based on the projected peak sun angle on the summer solstice.

5.16.2.3 Shading by trees.
Where shading is provided by trees, such trees shall be selected and placed in accordance with all of the following:

1. Trees selected shall be those that are native or adaptive to, the region and climate zone in which the project site is located. Invasive plant species shall not be selected. Plantings shall be selected and sited to produce a hardy and drought resistant vegetated area;
2. Construction documents shall be submitted that show the planting location and anticipated ten-year canopy growth of trees and that show the contributions of existing tree canopies; and
3. Shading calculations shall be shown on the construction documents demonstrating compliance with this Clause and shall include only those hardscape areas directly beneath the trees based on a ten-year growth canopy. Duplicate shading credit shall not be granted for those areas where multiple trees shade the same hardscape.
5.16.2.4 Pervious pavement and permeable unit pavement.

Pervious pavement and permeable unit pavement including open grid paving systems and open-graded aggregate systems shall have an infiltration rate not less than 2 gallons per minute per square foot (100 L/min × m²). The infiltration rate for pervious pavement shall be determined by testing in accordance with ASTM C1701/C1701M. The infiltration rate for permeable unit pavement shall be determined by testing in accordance with ASTM C1781/C1781M. Pervious pavement and permeable unit pavement shall be permitted where the use of these types of hardscapes does not interfere with fire and emergency apparatus or vehicle or personnel access and escape, utilities, or telecommunications lines. Aggregate used shall be open-graded to allow the pavement to comply with the infiltration rate.

5.16.3 Roof surfaces.

Not less than 75 percent of the roof surfaces of buildings and covered parking located in climate zones 1 through 3, as established in this Code, shall be a roof complying with Clause 5.16.3.1; shall be covered with a vegetative roof complying with Clause 4.8.3.2; or a combination of these requirements. The provisions of this Clause shall apply to roofs of structures providing shade to parking in accordance with Clause 5.16.2.2 where located in climate zones 1 through 6.

Exception: Portions of roof surfaces occupied by the following shall be permitted to be deducted from the roof surface area required to comply with this Clause:

- Solar thermal collectors.
- Solar photovoltaic systems.
- Roof penetrations and associated equipment.
- Portions of the roof used to capture heat for building energy technologies.
- Rooftop decks and rooftop walkways.
- Portions of roofs that are ballasted with a stone ballast of not less than 74 kg/m² (17 pounds per square foot) or 117 kg/m² (23 pounds per square foot) for pavers.

5.16.3.1 Roof coverings—solar reflectance and thermal emittance.

Where roof coverings are used for compliance with Clause 5.16.3, roof coverings shall comply with Clause 5.16.3.1.1 or 5.16.3.1.2. The values for solar reflectance and thermal emittance shall be determined by an independent laboratory accredited by a nationally recognized accreditation program. Roof products shall be listed and labeled and certified by the manufacturer demonstrating compliance.

<table>
<thead>
<tr>
<th>ROOF SLOPE</th>
<th>MINIMUM AGED SOLAR REFLECTANCE</th>
<th>MINIMUM AGED THERMAL EMITTANCE</th>
<th>MINIMUM AGED SRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:12 or less</td>
<td>0.575</td>
<td>0.75</td>
<td>64</td>
</tr>
<tr>
<td>Greater than 2:12</td>
<td>0.30</td>
<td>0.75</td>
<td>25</td>
</tr>
</tbody>
</table>

5.16.3.1.1 Roof products testing.

Roof products shall be tested for not less than three-year aged solar reflectance in accordance with ASTM E1918, ASTM C1549 or the CRRC-1 Standard and thermal emittance in accordance with ASTM C1371, ASTM E408 or the CRRC-1 Standard, and shall comply with the minimum values in Table 5.16.3.1.

5.16.3.1.2 Solar reflectance index.

Roof products shall be permitted to use a solar reflectance index (SRI) where the calculated value is in compliance with this code values for minimum aged SRI. The SRI value shall be determined using ASTM E1980 with a convection coefficient of 2.1 Btu/h-ft² (12 W/m² × k) based on three-year aged roof samples.
tested in accordance with the test methods in Clause 5.16.3.1.1.

5.16.3.2 Vegetative roofs.
Vegetative roofs, where provided in accordance with Clause 5.16.3, shall comply with the following:

1. All plantings shall be selected based on their hardiness zone classifications in accordance with this Code and shall be capable of withstanding the climate conditions of the jurisdiction and the microclimate conditions of the building site including, but not limited to, wind, precipitation, and temperature. Planting density shall provide foliage coverage, in the warm months, of not less than 80 percent within two years of the date of installation unless a different time period is established in the approved design. Plants shall be distributed to meet the coverage requirements. Invasive plant species shall not be planted.

2. The soil medium shall be designed for the physical conditions and local climate to support the plants and shall consist of nonsynthetic materials. The planting design shall include measures to protect the engineered soil medium until the plants are established. Protection measures include, but are not limited to, installation of pregrown vegetated mats or modules, tackifying agents, fiber blankets and reinforcing mesh. The maximum wet weight and water holding capacity of a soil medium shall be determined in accordance with ASTM E2399.

3. Where access to the building facades is provided from locations on the perimeter of the roof, nonvegetated buffers adequate to support associated equipment and to protect the roof shall be provided.

4. Nonvegetated clearances as required for fire classification of vegetative roof systems shall be provided in accordance with the Ghana Fire Code.

5. Plantings shall be capable of being managed to maintain the function of the vegetative roof as provided in the documents required by Clause 10.3.1.

6. Installation of plantings shall be in accordance with the roof covering manufacturer’s installation instructions and shall not diminish the weather protective properties of the roof covering.

5.17 SITE LIGHTING

5.17.1 Light pollution control.
Where this Clause is indicated to be applicable in this Code uplight, light trespass, and glare shall be limited for all exterior lighting equipment as described in Clause 5.17.2 and 5.17.3.

Exception: Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

1. Specialized signal, directional, and marker lighting associated with transportation.

2. Advertising signage or directional signage.

3. Lighting integral to equipment or instrumentation and installed by its manufacturer.

4. Theatrical purposes, including performance, stage, film production, and video production.

5. Athletic playing areas where lighting is equipped with hoods or louvers for glare control.

6. Temporary lighting.

7. Lighting for industrial production, material handling, transportation sites, and associated storage areas where lighting is equipped with hoods or louvers for glare control.

8. Theme elements in theme and amusement parks.

9. Roadway lighting required by governmental authorities.
10. Lighting used to highlight features of public monuments and registered landmark structures.

11. Lighting classified for and used in hazardous areas.

12. Lighting for swimming pools, spas and water features.

13. Lighting for the national flag in light pollution zones B, C and D.

5.17.1.1 Lighting pollution zones.
The light pollution zone for the building site shall be determined from Table 5.17.1.1 unless otherwise specified by the jurisdiction.

<table>
<thead>
<tr>
<th>LIGHT POLLUTION ZONE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rural and low-density residential areas such as, but not limited to: agricultural districts, one- and two-family residential communities, business parks, rural town centers, commercial or industrial areas with limited nighttime activity and the developed areas within parks and open space preserves.</td>
</tr>
<tr>
<td>B</td>
<td>Light commercial business districts and high-density or mixed-use residential districts such as, but not limited to: neighborhood business districts, light industrial areas with moderate nighttime activity, multifamily residential uses, institutional residential uses, hospitals, hotels, motels, churches, schools and neighborhood recreation facilities.</td>
</tr>
<tr>
<td>C</td>
<td>High-density commercial business districts, and heavy industrial or manufacturing areas such as, but not limited to: business districts in large cities, commercial corridors, high-density suburban commercial areas, town center mixed-use areas, industrial uses and shipping and rail yards with high nighttime activity, high-use recreation facilities, regional shopping malls, car dealerships, gas stations, and other exterior retail areas with high nighttime activity.</td>
</tr>
<tr>
<td>D</td>
<td>Areas such as, but not limited to: high-density entertainment districts and heavy industrial areas, where approved by the Code official.</td>
</tr>
</tbody>
</table>

5.17.2 Uplight.
Exterior lighting shall comply with the requirements of Table 5.17.2 for the light pollution zones (LZ) appropriate to the building site.

**Exception:** Lighting used for the following exterior applications shall be exempt from the requirements of Table 5.17.2.

<table>
<thead>
<tr>
<th>LIGHT POLLUTION ZONE (LPZ)</th>
<th>Maximum luminaire uplight rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>U1</td>
</tr>
<tr>
<td>B</td>
<td>U2</td>
</tr>
<tr>
<td>C</td>
<td>U3</td>
</tr>
<tr>
<td>D</td>
<td>U4</td>
</tr>
</tbody>
</table>

a. Uplight ratings (U) are defined by IES TM-15-07 Addendum A.
b. The rating shall be determined by the actual photometric geometry in the specified mounting orientation.
5.17.3 Light trespass and glare.
Where luminaires are mounted on buildings with their backlight oriented towards the building, such luminaires shall not exceed the applicable glare ratings specified in Table 5.17.3(2).

Table 5.17.3(1)
MAXIMUM GLARE RATINGS FOR BUILDING-MOUNTED LUMINAIRES WITH THE BACKLIGHT ORIENTED TOWARDS THE BUILDING

<table>
<thead>
<tr>
<th>HORIZONTAL DISTANCE TO LIGHTING BOUNDARY (H_{LB})</th>
<th>LIGHT POLLUTION ZONE (LPZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>h &lt; H_{LB} ≤ 2h m</td>
<td>G0</td>
</tr>
<tr>
<td>0.5 h &lt; H_{LB} ≤ h m</td>
<td>G0</td>
</tr>
<tr>
<td>H_{LB} &lt; 0.5 h m</td>
<td>G0</td>
</tr>
</tbody>
</table>

h = Mounting height: The distance above finished grade at which a luminaire is mounted, measured to the midpoint of the luminaire.

a. Glare (G) ratings are defined by IES TM-15-07 Addendum A.
b. The rating shall be determined by the actual photometric geometry in the specified mounting orientation.

c. The rating shall be determined by the actual photometric geometry in the specified mounting orientation.

Table 5.17.3(2)
MAXIMUM ALLOWABLE BACKLIGHT AND GLARE RATINGS

<table>
<thead>
<tr>
<th>HORIZONTAL DISTANCE TO LIGHTING BOUNDARY (H_{LB})</th>
<th>LIGHT POLLUTION ZONE (LPZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>h &lt; H_{LB} ≤ 2h m</td>
<td>B2</td>
</tr>
<tr>
<td>0.5 h &lt; H_{LB} ≤ h m</td>
<td>B1</td>
</tr>
<tr>
<td>H_{LB} &lt; 0.5 h m</td>
<td>B0</td>
</tr>
</tbody>
</table>

h = Mounting height: The distance above finished grade at which a luminaire is mounted, measured to the midpoint of the luminaire.

a. Backlight (B) and glare (G) ratings are defined by IES TM-15-07 Addendum A.
b. Luminaires located two mounting heights or less from the lighting boundary shall be installed with backlight towards the nearest lighting boundary, unless lighting a roadway, bikeway or walkway that intersects a public roadway.
c. The rating shall be determined by the actual photometric geometry in the specified mounting orientation.
PART 6: GENERAL BUILDING HEIGHTS AND AREAS

User note:
About this part: Part 6 establishes the limits to which a building can be built. Building height, number of stories and building area are specified in this part. Part 6 must be used in conjunction with the occupancies established in Part 3 and the types of construction established in Part 7. This part also specifies the impact that mezzanines, accessory occupancies and mixed occupancies have on the overall size of a building.

6.1 GENERA

6.1 Scope.
The provisions of this part control the height and area of structures hereafter erected and additions to existing structures.

6.2 BUILDING ADDRESS

6.2.1 Address identification.
New and existing buildings shall be provided with approved address identification. An approved identification system such as the GhanaPostGPS street Address System must be used in the application for building permits. The address identification shall be legible and placed in a position that is visible from the street or road fronting the property. Address identification characters shall contrast with their background. Address numbers shall be Arabic numbers or alphabetical letters. Numbers shall not be spelled out. Each character shall be a minimum of 102 mm (4 inches) high with a minimum stroke width of 12.7 mm (1/2 inch). Where required by the fire Code official, address identification shall be provided in additional approved locations to facilitate emergency response. Where access is by means of a private road and the building address cannot be viewed from the public way, a monument, pole or other approved sign or means shall be used to identify the structure. Address identification shall be maintained.

6.3 GENERAL BUILDING HEIGHT AND AREA LIMITATIONS

6.3.1 General.
Unless otherwise specifically modified in Part 4 and this part, building height, number of stories and building area shall not exceed the limits specified in Clause 6.4 and 6.9 based on the type of construction as determined by Clause 7.2 and the occupancies as determined by Clause 3.2 except as modified hereafter. Building height, number of stories and building area provisions shall be applied independently. For the purposes of determining area limitations, height limitations and type of construction, each portion of a building separated by one or more fire walls complying with Clause 8.6 shall be considered to be a separate building.

6.3.1.1 Special industrial occupancies.
Buildings and structures designed to house special industrial processes that require large areas and unusual building heights to accommodate craneways or special machinery and equipment, including, among others, rolling mills; structural metal fabrication shops and foundries; or the production and distribution of electric, gas or steam power, shall be exempt from the building height, number of stories and building area limitations specified in Clause 6.4 and 6.9.

6.3.1.2 Buildings on same plot.
Two or more buildings on the same plot shall be regulated as separate buildings or shall be considered as portions of one building where the building height, number of stories of each building and the aggregate building area of the buildings are within the limitations specified in Clause 6.4 and 6.9. The provisions of this Code applicable to the aggregate building shall be applicable to each building.

6.3.1.3 Type I construction.
Buildings of Type I construction permitted to be of unlimited tabular building heights and areas are not subject to the special requirements that allow unlimited area buildings in this Code or unlimited building height in Clauses 6.3.1.1 and 6.4.3 or increased building heights and areas for other types of construction.

6.3.1.4 Occupied roofs.
A roof level or portion thereof shall be permitted to be used as an occupied roof provided the
occupancy of the roof is an occupancy that is permitted by Table 6.4.4 for the storey immediately below the roof. The area of the occupied roofs shall not be included in the building area as regulated by Clause 6.9.

Exceptions:

1. The occupancy located on an occupied roof shall not be limited to the occupancies allowed on the storey immediately below the roof where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and occupant notification in accordance with Clause 10.7.5 is provided in the area of the occupied roof.

2. Assembly occupancies shall be permitted on roofs of open parking spaces of Type I or Type II construction, in accordance with the exception to Clause 10.3.2.1.6.

6.3.1.4.1 Enclosures over occupied roof areas.

Elements or structures enclosing the occupied roof areas shall not extend more than 1220 mm (48 inches) above the surface of the occupied roof.

Exception: Penthouses constructed in accordance with Clause 16.10.2 and towers, domes, spires and cupolas constructed in accordance with Clause 16.10.5.

6.4 BUILDING HEIGHT AND NUMBER OF STORIES

6.4.1 General.

The height, in feet, and the number of stories of a building shall be determined based on the type of construction, occupancy classification and whether there is an automatic sprinkler system installed throughout the building.

Exception: The building height of one-storey aircraft hangars, aircraft paint hangars and buildings used for the manufacturing of aircraft shall not be limited where the building is provided with an automatic sprinkler system or automatic fire-extinguishing system in accordance with Part 10 and is entirely surrounded by public ways or yards not less in width than one and one-half times the building height.

6.4.1.1 Unlimited area buildings.

The height of unlimited area buildings shall be designed in accordance with Clause 6.10.

6.4.1.2 Special provisions.

The special provisions of Clause 6.13 permit the use of special conditions that are exempt from, or modify, the specific requirements of this part regarding the allowable heights of buildings based on the occupancy classification and type of construction, provided the special condition complies with the provisions specified in Clause 6.13.

6.4.2 Mixed occupancy.

In a building containing mixed occupancies in accordance with Clause 6.11, no individual occupancy shall exceed the height and number of storey limits specified in this clause for the applicable occupancies.

6.4.3 Height in feet.

The maximum height, in feet, of a building shall not exceed the limits specified in Table 6.4.3.

Exception: Towers, spires, steeples and other roof structures shall be constructed of materials consistent with the required type of construction of the building except where other construction is permitted by Clause 16.10.2.4. Such structures shall not be used for habitation or storage. The structures shall be unlimited in height where of non-combustible materials and shall not extend more than 6096 mm (20 feet) above the allowable building height where of combustible materials (Part 16 for additional requirements).
### TABLE 6.4.3
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>TYPE OF CONSTRUCTION</th>
<th>SEE FOOTNOTES</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>A, B, E, F, M, S, U</td>
<td>NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>H-1, H-2, H-3, H-5</td>
<td>NS&lt;sup&gt;c, d&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>H-4</td>
<td>NS&lt;sup&gt;c, d&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>I-1 Condition 1, I-3</td>
<td>NS&lt;sup&gt;d, e&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>I-1 Condition 2, I-2</td>
<td>NS&lt;sup&gt;d, e, f&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>I-4</td>
<td>NS&lt;sup&gt;d, g&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
<tr>
<td>R&lt;sup&gt;h&lt;/sup&gt;</td>
<td>NS&lt;sup&gt;d&lt;/sup&gt;</td>
<td>UL</td>
<td>160</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>UL</td>
<td>180</td>
<td>85</td>
<td>75</td>
<td>85</td>
<td>75</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
UL = Unlimited; NS = Buildings not equipped throughout with an automatic sprinkler system; S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.33.1.1; S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.33.1.2; S13D = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.33.1.3.

a. See Parts 4 and 5 for specific exceptions to the allowable height in this part.
b. See Clause 10.32 for the minimum thresholds for protection by an automatic sprinkler system for specific occupancies.
c. New Group H occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.32.5.
d. The NS value is only for use in evaluation of existing building height in accordance with the International Existing Building Code.
e. New Group I-1 and I-3 occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.32.6. For new Group I-1 occupancies Condition 1, see Exception 1 of Clause 10.32.6.
f. New and existing Group I-2 occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.32.6 and the Ghana Fire Code.
g. For new Group I-4 occupancies, see Exceptions 2 and 3 of Clause 10.32.6.
h. New Group R occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.32.8.

### 6.4.4 Number of stories.

The maximum number of stories of a building shall not exceed the limits specified in Table 6.4.4.
## TABLE 6.4.4
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE\(^a, b\)

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>SEE FOOTNOTES</th>
<th>TYPE OF CONSTRUCTION</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
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\(^a\) See Footnote 4.4.4
\(^b\) See Footnote 4.4.4
### TABLE 6.4.4—continued

**ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE**

<table>
<thead>
<tr>
<th>OCCUPANCY CLASS</th>
<th>SEE FOOTNOTES</th>
<th>TYPE OF CONSTRUCTION</th>
<th>TYPE I</th>
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<th>TYPE III</th>
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<th>TYPE V</th>
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<td><strong>B</strong></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

UL = Unlimited; NP = Not Permitted; NS = Buildings not equipped throughout with an automatic sprinkler system; S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.; S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.2.; S13D = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.3.

a. See Parts 5 and 6 for specific exceptions to the allowable height in this part.

b. See Clause 10.3.2 for the minimum thresholds for protection by an automatic sprinkler system for specific occupancies.

c. New Group H occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.5.

d. The NS value is only for use in evaluation of existing building height in accordance with the International Existing Building Code.

e. New Group I-1 and I-3 occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.6. For new Group I-1 occupancies, Condition 1, see Exception 1 of Clause 10.3.2.6.

f. New and existing Group I-2 occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.6 and the Ghana Fire Code.

g. For new Group I-4 occupancies, see Exceptions 2 and 3 of Clause 10.3.2.6.

h. New Group R occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.8

#### 6.5 AREA AND HEIGHT LIMITATIONS

**6.5.1 General**

The limitation of area and height of buildings of different occupancy classes and types of construction shall be achieved by specifying it in terms of FAR (or FSI), which shall take into account the various aspects that govern in specifying FAR as given below:

- Occupancy class;
- Types of construction;
- Width of street fronting the building and the traffic load;
- Locality where the building is proposed and the density;
- Parking facilities;
- Local fire fighting facilities; and
- Water supply and drainage facilities.

**6.5.2** The comparative FAR's for different occupancies and types of construction are as given in Table 6.5.1 and the Authority shall select a basic FAR for one occupancy and a type of construction and arrive at the FAR values for other combinations taking into account the other local factors see 6.5.1.
6.5.2.1 Unlimited Areas

The minimum fire separation on all sides of buildings of unlimited areas (see Table 6.5.1) and of Type 1 construction shall be 9m.

6.5.3 Street Width

The area limits shall apply to all buildings fronting on a street or public space not less than 9m in width accessible to a public street.

6.5.4 Height Limit

The height and number of storeys shall be related to FAR and the provisions of this Code.

6.5.4.1 Where a building height is not covered by Table 6.5.1, the maximum height shall be limited according to the width of the street as follows:

a) the maximum height of building shall not exceed 1.5 times the width of road abutting plus the front open space;

b) if a building abuts on two or more streets of different widths, the building shall be deemed to face upon the street that has the greater width and the height of the building shall be regulated by the width of that street and may be continued to this height to a depth of 24m along the narrower street subject to conformity of this Code and

c) for buildings in the vicinity of aerodromes, provisions of Clause 6.5.5 shall apply.

6.5.4.2 Height Exceptions

6.5.4.2.1 Roof Structures

The following appurtenant structures shall not be included in the height of the building unless the aggregate area of such structures, including pent-houses, exceeds one-third of the area of the roof of building upon which they are erected:

a) roofs tanks and their supports;
b) ventilating, air-conditioning, lift rooms and similar service equipment;
c) roof structures other than pent-houses; and
d) chimneys and parapet walls not exceeding 1m in height.

---

**TABLE 6.5.1 - Comparative Floor Area Ratios for Occupancies Facing one Public Street of at Least 9m Width**

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>TYPE OF CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type 1</td>
</tr>
<tr>
<td>Residential</td>
<td>UL</td>
</tr>
<tr>
<td>Educational</td>
<td>UL</td>
</tr>
<tr>
<td>Institutional</td>
<td>UL</td>
</tr>
<tr>
<td>Assembly</td>
<td>UL</td>
</tr>
<tr>
<td>Business</td>
<td>UL</td>
</tr>
<tr>
<td>Mercantile</td>
<td>8.0</td>
</tr>
<tr>
<td>Industrial</td>
<td>7.5</td>
</tr>
<tr>
<td>Storage (see Note 4)</td>
<td>6.0</td>
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<tr>
<td>Hazardous (see Note 4)</td>
<td>2.8</td>
</tr>
</tbody>
</table>
UL – Unlimited  
NP – Not Permitted

Note 1 – This table has been prepared, taking into account the combustible content in the different occupancies as well as the fire resistance offered by the type of construction (see Part 3 Use and Occupancy).

Note 2 – This table shall be modified by the Authority, taking into account the other aspects as given below (see 6.5.1).

   a)  density in terms of dwelling units/hectare;  
   b)  traffic considerations; 
   c)  parking spaces;  
   d)  local fire fighting facilities; and 
   e)  water supply, drainage and sanitation requirements.

Note 3 – The FAR specified may be increased by 20 percent for the following:

   a) a basement or cellar and space under a building constructed on stilts and used as a parking space, and air-conditioning plant room used as accessory to the principal use;
   b) electric cabin or substation, watchman’s booth of maximum size of 1.6m² with minimum width or diameter of 1.2m, pump house, garbage shaft, space required for location of fire hydrants, electric fittings and water tank;  
   c) projections and accessory buildings as specifically exempted; and  
   d) staircase room and lift rooms above the topmost storey, architectural features; and chimneys and elevated tanks of dimensions as permissible under the Code, the area of the lift shaft shall be taken only on one floor.

Note 4 – In so far as single storey storage and hazardous occupancies are concerned, they would be further governed by volume to plot area ratio (VPR), to be decided by the Authority.

6.5.4.2.2 Except in buildings where automatic sprinkler system is a requirement in accordance with Part 3 Use and Occupancy, all structures of Type 1, Type 2 and Type 3 construction designed for industrial, business, mercantile, low or moderate hazard storage occupancies may be erected 6m higher than specified in Table 6.5.1 when equipped with an approved one-source automatic sprinkler system.

6.5.5 Restrictions in the vicinity of Aerodromes

6.5.5.1 For buildings in the vicinity of aerodromes, the maximum height of such buildings shall be decided in consultation with the Ghana Civil Aviation Authority. This shall be regulated by the rules for giving no objection certificate for construction of buildings in the vicinity of aerodromes by the Director General of Civil Aviation, which are given in Appendix A. However, the latest rules of the Ghana Civil Aviation Authority shall be followed in all cases of buildings coming up in the vicinity of an aerodrome.

6.5.5.1.1 For the purpose of 6.5.5.1, new buildings structures which rise to 30m or more in height and are to be located within 20 km of the aerodrome reference point, shall be constructed only if a no objection certificate has been obtained from the Director General of Civil Aviation.

6.5.5.1.2 In the case of buildings to be erected in the vicinity of defence aerodromes, the maximum height of such buildings shall be decided by the Defence Authority.

6.5.5.2 This will apply specially to new constructions, overhead HT/LT lines, telephone/telegraph lines, factories, chimneys, wire/TV antennas.

6.5.5.2.1 No new chimneys or smoke producing factories shall be constructed within a radius of 8 km from the aerodrome reference point (ARP).

6.5.5.2.2 Overhead HT/LT lines or telephone/telegraph lines shall not be permitted in the approach/take-off climb areas within 3000m of the inner edge of these areas.

6.5.5.2.3 A 3m margin shall be allowed in new constructions for wireless/TV antennas and cooling towers.

6.5.5.3 Butcheries, tanneries and solid waste disposal sites shall not be permitted within 10 km from the aerodrome reference point.

6.5.6 Group Housing

6.5.6.1 Group housing development may normally and preferably be in multi storeyed blocks; it shall not be a customary subdivision of land into streets and plots.

6.5.6.2 No limit to floors and height shall be applicable, but the coverage and floor area
ratio for various densities may be as given in Table 6.5.2 unless otherwise provided in the Master Plan and local development control rules.

Table 6.5.2 - Floor Area Ratio and Coverage for Group Housing

<table>
<thead>
<tr>
<th>Row No.</th>
<th>Gross Residential Density Persons/Hectare</th>
<th>Maximum coverage in Percent</th>
<th>Floor Area Ratio</th>
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</thead>
<tbody>
<tr>
<td>i)</td>
<td>125</td>
<td>25</td>
<td>0.75</td>
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<tr>
<td>ii)</td>
<td>250</td>
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<tr>
<td>v)</td>
<td>625</td>
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<td>2.00</td>
</tr>
</tbody>
</table>

Note – The coverage shall be calculated on the basis of the whole area reserved for group housing after deducting:

a) the area of any highway, any road up to 25m and major residential roads of 18m width around the group housing area (residential street, loop street, cul-de-sac, service lanes and footpaths shall not be deducted);

b) the area of school (excluding sites for nursery schools) and other community facilities within the group housing area; and

c) the open spaces, except playgrounds of local nature.

6.6 REQUIREMENTS OF PARTS OF BUILDINGS

6.6.1 Plinth

6.6.1.1 Main Buildings

The plinth or any part of a building or outhouse shall be so located with respect to the surrounding ground level that adequate drainage of the site is assured. The height of the plinth shall be not less than 450mm from the surrounding ground level.

6.6.1.2 Interior Courtyards

Every interior courtyard shall be raised at least 150mm above the level of the centre of the nearest street and shall be satisfactorily drained.

6.6.2 Habitable Rooms

6.6.2.1 Height

The height of all rooms for human habitation shall not be less than 2.75m measured from the surface of the floor to the lowest point of the ceiling (bottom of slab). In the case of pitched roof, the average height of rooms shall not be less than 2.75m. The minimum clear head room under a beam, folded plates or eaves shall be 2.4m. In the case of air-conditioned rooms, a height of not less than 2.4m measured from the surface of the floor to the lowest point of air-conditioning duct or the false ceiling shall be provided.

6.6.2.1.1 The requirements of 6.6.2.1 apply to residential, business and mercantile buildings. For educational and industrial buildings, the following minimum requirements apply:

<table>
<thead>
<tr>
<th>a) Educational buildings</th>
<th>Ceiling height 3.6m for all regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Industrial buildings</td>
<td>Ceiling height 3.6m, except when air-conditioned, 3m (Factory Act 1948 and rules therein shall govern such heights, where applicable).</td>
</tr>
</tbody>
</table>

6.6.2.2 Size

The area of habitable room shall not be less than 9.5m², where there is only one room with a minimum width of 2.4m. Where there are two rooms, one of these shall not be less than 9.5m² and the other not less than 7.5m², with a minimum width of 2.1m.

6.6.3 Kitchen

6.6.3.1 Height

The height of a kitchen measured from the surface of the floor to the lowest point in the ceiling (bottom slab) shall not be less than 2.75m, except for the portion to accommodate floor trap of the upper floor.
6.6.3.2 Size

The area of a kitchen where separate dining area is provided, shall be not less than 5.0m² with a minimum width of 1.8m. Where there is a separate store, the area of the kitchen may be reduced to 4.5m². A kitchen, which is intended for use as a dining area also, shall have a floor area of not less than 7.5m² with a minimum width of 2.1m.

6.6.3.3 Other Requirements

Every room to be used as kitchen shall have:

a) unless separately provided in a pantry, means of the washing of kitchen utensils which shall lead directly or through a sink to a grated and trapped connection to the waste pipe;

b) an impermeable floor;

c) a flue, if found necessary; and

d) a window or ventilator or opening of size not less than as specified in this Code, subject to increase in area of opening in accordance with Note 3 of this Code.

6.6.4 Bathrooms and Water-Closets

6.6.4.1 Height

The height of a bathroom or water-closet measured from the surface of the floor to the lowest point in the ceiling (bottom of slab) shall not be less than 2m.

6.6.4.2 Size

The size of a bathroom shall not be less than 1.5 x 1.2m or 1.8m². The floor area of water-closet shall be 1.1m² with a minimum width of 0.9m. If bath and water-closet are combined, its floor area shall not be less than 2.8m² with a minimum width of 1.2m.

6.6.4.3 Other Requirements

Every bathroom or water-closet shall:

a) be so situated that at least one of its walls shall open to external air;

b) not be directly over or under any room other than another water-closet, washing place, bath or terrace, unless it has a water-tight floor;

c) have the platform or seat made of water-tight non-absorbent material;

d) be enclosed by walls or partitions and the surface of every such wall per partition shall be finished with a smooth impervious material to a height of not less than 1m above the floor of such a room;

e) be provided with an impervious floor covering, sloping towards the drain with a suitable grade and not towards verandah or any other room; and

f) have a window or ventilator, opening to a shaft or open space, of area not less than 0.3m² with side not less than 0.3m.

6.6.4.4 No room containing water-closets shall be used for any purpose except as a lavatory and no such room shall open directly into any kitchen or cooking space by a door, window or other opening. Every room containing water-closet shall have a door completely closing the entrance to it.

6.6.5 Ledge or Loft

6.6.5.1 Height

It shall have a minimum head-room of 2.2m.

6.6.5.2 Size

A ledge in a habitable room shall not cover more than 25 percent of the area of the floor on which it is constructed and shall not interfere with the ventilation of the room under any circumstances.

6.6.5.3 Loft

The maximum height of loft shall be 1.5m. A loft, if provided, on a kitchen, shall not exceed 25 percent of the area of the kitchen, leaving minimum headroom of 2.2m for the kitchen under the loft. On bathroom, water-closet and corridor, the loft can be 100 percent.

6.6.6 Mezzanine floor

6.6.6.1 Height

It shall have a minimum height of 2.2m.
6.6.6.2 Size
The minimum size of the mezzanine floor, if it is to be used as a living room, shall not be less than 9.5m². The aggregate area of such mezzanine floor in a building shall in no case exceed one-third the plinth area of the building.

6.6.6.3 Other Requirements
A mezzanine floor may be permitted over a room or a compartment provided:

a) it conforms to the standards of living rooms as regards lighting and ventilation in case the size of mezzanine floor is 9.5m² or more
b) it is so constructed as not to interfere under any circumstances with the ventilation of the space over and under it;
c) such mezzanine floor is not subdivided into smaller compartments;
d) such mezzanine floor or any part of it shall not be used as a kitchen; and
e) in no case shall a mezzanine floor be closed so as to make it liable to be converted into unventilated compartments.

6.6.7 Store Room

6.6.7.1 Height
The height of a store room shall be not less than 2.2m.

6.6.7.2 Size
The size of a store room, where provided in a residential building, shall be not less than 3m.

6.6.8 Garage

6.6.8.1 Height
The height of a garage shall not be less than 2.4m.

6.6.8.2 Size
The size of garages shall be as below:

a) Private garage – 2.5 x 5.0m, minimum; and
b) Public garage – based on the number of vehicles parked, etc.

6.6.9 Basement

6.6.9.1 The basement shall not be used for residential purposes.

6.6.9.2 The construction of the basement shall be allowed by the authority in accordance with the land use and other provisions specified under the Development Control Rules.

6.6.9.2.1 The basement to be constructed within the prescribed set-backs and prescribed building lines and subject to maximum coverage on floor 1 (entrance floor) may be put to only the following uses:

a) storage of household or other goods of ordinarily combustible material;
b) strong rooms, bank cellars, etc.
c) air-conditioning equipment and other machines used for services and utilities of the building; and
d) parking spaces.

6.6.9.3 The basement shall have the following requirements.

a) Every basement shall be in every part at least 2.4m in height from the floor to the underside of the roof slab or ceiling.

b) Adequate ventilation shall be provided for the basement. The ventilation requirements shall be the same as required by the particular occupancy according to byelaws. Any deficiency may be met by providing adequate mechanical ventilation in the form of blowers, exhaust fans, air-conditioning systems, etc.

c) The minimum height of the ceiling of any basement shall be 0.9m and the maximum,
1.2m above the average surrounding ground level.

d) Adequate arrangements shall be made such that surface drainage does not enter the basement.

e) The walls and floors of the basement shall be watertight and be so designed that the effects of the surrounding soil and moisture, if any, are taken into account in design and adequate damp proofing treatment is given.

f) The access to the basement shall be separated from the main and alternative staircase providing access and exit from higher floors. Where the staircase is continuous in the case of buildings served by more than one staircase, the same shall be of enclosed type serving as a fire separation from the basement floor and higher floors. Open ramps shall be permitted if they are constructed within the building line subject to the provision of (d).

6.6.10 Chimneys

The chimneys shall be built at least 0.9m above flat roofs, provided the top of the chimney is not below the top of the adjacent parapet wall. In the case of sloping roofs, the chimney top shall not be less than 0.6m above the ridge of the roof in which the chimney penetrates.

6.6.11 Parapet

Parapet walls and handrails provided on the edges of roof terraces, balcony, verandah, etc. shall not be less than 1.05m and not more than 1.20m in height from the finished floor level.

6.6.12 Cabin

The size of cabins shall not be less than 3.0m$^2$. The clear passages within the divided space of any floor shall not be less than 0.75m and the distance from the farthest space in a cabin to any exit shall not be more than 18.5m. In case the subdivided cabin does not derive direct lighting and ventilation from any open spaces/mechanical means, the maximum height of the cabin shall be 2.2m.

6.6.13 Boundary Wall

6.6.13.1 The requirements of the boundary wall are given below:

a) Except with the special permission of the Authority, the maximum height of the compound wall shall be 1.5m above the centre line of the front street. Compound walls up to 2.5m height may be permitted if the top 0.9m is of open type construction of a design to be approved by the Authority.

b) In the case of a corner plot, the height of the boundary wall shall be restricted to 0.75m for a length of 10m on the front and side of the interclauses and the balance height of 0.75m if required in accordance with (a) may be made up of open type construction (through railings, breeze blocks etc.) and of design to be approved by the Authority.

c) However, the provisions of (a) and (b) are not applicable to boundary walls of jails. In industrial buildings, electric substations, transformer stations, institutional buildings like sanitoria, hospitals, industrial buildings like workshops, factories and educational buildings like schools, colleges, including hostels and other uses of public utility undertakings, heights up to 2.4m may be permitted by the Authority.

6.6.14 Wells

Wells, intended to supply water for human consumption or domestic purposes, where provided, shall comply with the requirements of 6.6.14.1 and 6.6.14.2.
6.6.14.1 Location

The well shall be located:

a) not less than 15m from any ash pit, refuse pit, earth closet or privy and shall be located on a site upwards from the earth closet or privy;

b) not less than 18m from any cesspit soakaway or borehole latrine and shall be located on a site upwards from the earth closet or privy;

c) that contamination by the movement of sub-soil or other water is unlikely; and

d) not under a tree or otherwise it should have a canopy over it, so that leaves and twigs may not fall into the well and rot.

6.6.14.2 Requirements

The well shall:

a) have a minimum internal diameter of not less than 1m;

b) be constructed to a height not less than 1m above the surrounding ground level, to form a parapet or kerb and to prevent surface water from flowing into well, and shall be surrounded with a paving constructed of impervious material which shall extend for a distance of not less than 1.8m in every direction from the parapet from the kerb forming the well head and the upper surface of such a paving shall be sloped away from the well;

c) be of sound and permanent construction throughout. Temporary or exposed wells shall be permitted only in fields or gardens for purposes of irrigation; and

d) have the interior surface of the lining or walls of the well rendered impervious for a depth of not less than 1.8m measured from the level of the ground immediately adjoining the well-head.

6.6.15 Septic Tanks

Where a septic tank is used for sewage disposal, the location, design and construction of the septic tank shall conform to requirements of 6.6.15.1 and 6.6.15.2.

6.6.15.1 Location of Septic Tanks and Subsurface Absorption Systems

A subsoil dispersion system shall not be closer than 18m from any source of drinking water, such as well, to mitigate the possibility of bacterial pollution of water supply. It shall also be far removed from the nearest habitable building as economically feasible but not closer than 6m, to avoid damage to the structures.

6.6.15.2 Requirements

a) Dimensions of Septic Tanks – Septic tanks shall have a minimum width of 750mm, a minimum depth of 1 m below the water level and a minimum liquid capacity of 1m³. The length of tanks shall be 2 to 4 times the width.

b) Septic tanks may be constructed of brickwork, stone masonry, concrete or other suitable materials as approved by the Authority.

c) Under no circumstances shall effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment.

d) The minimum nominal diameter of the pipe shall be 100 mm. Further, at junctions of pipes in manholes, direction of flow from a branch connection shall not make an angle exceeding 45° with the direction of flow in the main pipe;

e) The gradients of land drains, under-drainage as well as the bottom of dispersion trenches and soakaways shall be between 1:300 and 1:400;

f) Every septic tank shall be provided with ventilating pipe of at least 50
mm diameter. The top of the pipe shall be provided with a suitable cage of mosquito-proof wire mesh;

The ventilating pipe shall extend to a height which would cause no smell nuisance to any building in the area. Generally, the ventilating pipe may extend to a height of about 2m, when the septic tank is at least 15 m away from the nearest building and to a height of 2m above the top of the building when it is located closer than 15m;

g) When the disposal of septic tank effluent is to a seepage pit, the seepage pit may be of any suitable shape with the least cross-clausal dimension of 900mm and not less than 1000mm in depth below the invert level of the inlet pipe. The pit may be lined with stone, brick or concrete blocks with dry open joints which should be backed with at least 75mm of clean coarse aggregate. The lining above the inlet level should be finished with mortar. In the case of pits of large dimensions, the top portion may be narrowed to reduce the size of the RCC cover slabs. Where no lining is used, especially near trees, the entire pit should be filled with stones. A masonry ring may be constructed at the top of the pit to prevent damage by flooding of the pit by surface runoff. The inlet pipe may be taken down a depth of 900mm from the top as an anti-mosquito measure; and

h) When the disposal of the septic tank effluent is to a dispersion trench, the dispersion trench shall be 500 to 1000mm deep and 300 to 1000mm wide excavated to a slight gradient and shall be provided with 150 to 250mm of washed gravel or crushed stones. Open jointed pipes placed inside the trench shall be made of unglazed earthenware clay or concrete and shall have a minimum internal diameter of 75 to 100 mm. Each dispersion trench shall not be longer than 30m and trenches shall not be placed closer than 1.8 m.

6.6.16 Office-cum-Letter Box Room

In the case of multi-storeyed, multi-family dwelling apartments constructed by existing and proposed Real Estate or Apartment Owners Associations, Limited companies and proposed housing societies, an office-cum-letter box room of dimension 3.6 x 3m shall be provided on the ground floor. In case the number of flats is more than 20, the maximum size of the office-cum-letter box room shall be 20 m².

6.6.16.1 Business Building

Provision shall be made for letter boxes on the entrance floor as per the requirements of the postal department.

6.6.17 Meter Rooms

For all buildings above 15m in height and in special occupancies, like educational, assembly, institutional, industrial, storage, hazardous and mixed occupancies with any of the aforesaid occupancies having area more than 500 m² on each floor, provision shall be made for an independent and ventilated meter (service) room, as per requirements of electric (service) supply undertakings on the ground floor with direct access from outside for the purpose of termination of electric supply form the licensee’s service and alternative supply cables. The door/doors provided for the service room shall have fire resistance of not less than two hours.

6.6.18 Staircase

6.6.18.1 The minimum clear width, minimum tread width and maximum riser of staircases for buildings shall be as given in 6.6.18.1 to 6.6.18.1.3 (See also Part 3 Use and Occupancy).

6.6.18.1.1 Minimum Width

The minimum width of staircase shall be as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Minimum Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Residential</td>
<td>1.0m</td>
</tr>
<tr>
<td>buildings (dwellings)</td>
<td></td>
</tr>
<tr>
<td>Note – For row</td>
<td></td>
</tr>
<tr>
<td>housing with 2 storeys, the minimum width shall be 0.75m</td>
<td></td>
</tr>
<tr>
<td>b) Residential</td>
<td>1.5m</td>
</tr>
<tr>
<td>hotel buildings</td>
<td></td>
</tr>
</tbody>
</table>
c) Assembly buildings like auditoria, theatres and cinemas 1.5m

d) Educational building up to 24m in height 1.5m

e) Institutional buildings up to 10 beds and more than 10 beds 2.0m

f) All other buildings 1.5m

6.6.18.1.2 Minimum Tread

The minimum width of tread without nosing shall be 250mm for residential buildings. The minimum width of tread for other buildings shall be 300mm.

6.6.18.1.3 Maximum Riser

The maximum height of riser shall be 190mm for residential buildings and 150mm for other buildings and these shall be limited to 15 per flight.

6.6.18.2 Minimum headroom

The minimum head-room in a passage under the landing of a staircase shall any staircase shall be 2.2m.

6.6.19 Roofs

6.6.19.1 The roof of a building shall be so constructed or framed as to permit effectual drainage of the rain-water therefrom by means of sufficient rain-water pipes of adequate size, wherever required, so arranged, jointed and fixed as to ensure that the rain-water is carried away from the building without causing dampness in any part of the walls or foundations of the building or those of an adjacent building.

6.6.19.2 The Authority may require rain-water pipes to be connected to a drain or sewer to a covered channel formed beneath the public footpath to connect the rain-water pipe to the road gutter or in any other approved manner.

6.6.19.3 Rain-water pipes shall be affixed to the outside of the external walls of the building or in recesses or chases cut on formed in such external walls or in such other manner as may be approved by the Authority.

6.6.20 Special requirements of low income housing shall be as given in Appendix D. For detailed information in this regard, reference may be made this Code.

6.6.21 Special requirements for the physically handicapped

- The special requirements for planning of buildings keeping in view the needs of the physical handicapped, applicable particularly to public buildings meant for their use, are given in Appendix E.

6.7 RODENT-PROOFING AND TERMITE-PROOFING OF BUILDINGS

6.7.1 Every building or part thereof that is designed or intended for use as a dwelling or for the handling, storage or sale of foodstuffs shall conform to the requirements as given in 6.7.2 and 6.7.3.

6.7.2 Every such building unless supported on posts shall have continuous foundation walls, extending from at least 600mm below ground level to at least 150mm above ground level or shall have a continuous floor of masonry or reinforced concrete or other equally effective rat-proof materials.

6.7.3 All openings in such foundations or floors, windows and drains, and all junctions between foundation walls and building walls shall be effectively rat-proofed, that is, windows and doors shall be tight fitting, and other openings shall be securely covered with rat-proof screening or grillage or shall be tightly closed with metal sheeting, concrete or other equally effective rat-proof material.

6.7.4 Termite control in buildings is very important, as the damage likely to be caused by termites to wooden structures of buildings and other household articles like furniture, clothing, stationery, etc. is considerable. Anti-termite measures in buildings shall be taken in accordance with this Code.
APPENDIX A

CIVIL AVIATION REQUIREMENTS FOR CONSTRUCTION IN THE VICINITY OF AN AERODROME

A-0 GENERAL

A-0.1 For the purpose of this Appendix, the following definitions shall apply.

A-0.1.1 Aerodrome Reference Point (ARP)

This is a designated point, which is established in the horizontal plane at or near the geometric centre of the landing area.

A-0.1.2 Approach Funnel

See Fig.A.1

A-0.1.3 Elevation or Reduced Level

This is the vertical distance of a point or a level, on or affixed to the surface of the earth, measured from the mean sea level.

A-0.1.4 Transitional Area

It is an area which is below a specified surface sloping upwards and outwards from the edge of the approach funnel and from a line originating at the end of the inner edge of each approach area, drawn parallel to the runway centre line in the direction of landing (See Fig. A.1).

A-1 PROHIBITED AREA

A-1.1 No building or structure shall be constructed or erected, or no tree shall be planted, on any land within the limits specified in A-1.2 and A-1.3 in respect of the aerodromes listed by the Ghana Civil Aviation Authority.

A-1.2 For the Aerodromes listed by the Ghana Civil Aviation Authority

These requirements shall be applicable for the land enclosed in approach funnels of the runway with a maximum distance of 360m measured from each runway and along the extend centre line of the runway. For the purpose of this clause, the requirements of approach funnel and an instrument runway shall be given in A-1.2.1 to A-1.2.3.

A-1.2.1 Approach funnel in the case of an instrument runway means the area in the shape of an isosceles trapezium having the longer parallel side 4800m long (2400m on either side of the extended centre line of the runway) and smaller parallel side 300m long (150m on either side of the extended centre line of the runway) where the smaller and longer parallel sides are placed at a distance of 60m and 15060m, respectively, from the end of the runway and at right angles to the extended centre line.
1B - Instrument Runway

All Dimensions are in Metres

A-1.2.2 In the case of a non-instrument runway, the approach funnel means the area in the shape of an isosceles trapezium having the longer parallel side 1800m long (900 m on either side of the extended centre line of the runway) and smaller parallel side 180m long (90m on either side of the extended centre line of the runway), where the smaller and longer parallel sides are placed at a distance of 60m and 6540m, respectively, from the end of the centre line. Thereafter, the trapezium is followed by a contiguous rectangular area of that width for the remainder of the length up to a distance of 15060m from the end of the runway.

A-1.2.3 An instrument runway is a runway served by visual and non-visual aid or aids providing at least directional guidance adequate for a straight in approach and intended for the operation of aircraft using instrument approach procedures.

A-2 HEIGHT RESTRICTION

A-2.1 For the aerodromes listed by the Ghana Civil Aviation Authority

No building or structure higher than the height specified in Tables 4.5 and 4.6 shall be constructed or erected, or no tree which is likely to grow or ordinarily grows higher than the height specified in the Tables 4.5 and 4.6, shall be planted, on any land within a radius of 20 km from ARP of the aerodromes listed in A-3, excluding the land covered by A-1.2.

Table 4.5 - Height Restriction with respect to Approach Funnels

(Clauses A-2.1 and A-2.1.1)

<table>
<thead>
<tr>
<th>Col. No.</th>
<th>Area</th>
<th>Maximum Permissible height above the Elevation of the Nearest Runway End m</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>More than 360m but not exceeding 510m</td>
<td>6</td>
</tr>
<tr>
<td>ii)</td>
<td>More than 510m but not exceeding 660m</td>
<td>9</td>
</tr>
<tr>
<td>iii)</td>
<td>More than 660m but not exceeding 810m</td>
<td>12</td>
</tr>
<tr>
<td>iv)</td>
<td>More than 810m but not exceeding 960m</td>
<td>15</td>
</tr>
<tr>
<td>v)</td>
<td>More than 960m but not exceeding 1110m</td>
<td>18</td>
</tr>
<tr>
<td>vi)</td>
<td>More than 1110m but not exceeding 1260m</td>
<td>21</td>
</tr>
<tr>
<td>vii)</td>
<td>More than 1260m but not exceeding 1410m</td>
<td>24</td>
</tr>
<tr>
<td>viii)</td>
<td>More than 1410m but not exceeding 1560m</td>
<td>27</td>
</tr>
<tr>
<td>ix)</td>
<td>More than 1560m</td>
<td>30</td>
</tr>
</tbody>
</table>
### Table 4.6 - Height Restriction with respect to Transitional Area
(Clauses A-2.1 and A-2.1.2)

<table>
<thead>
<tr>
<th>Col. No.</th>
<th>Distance from the inner Boundary of the 'Transitional Area' Specified Above</th>
<th>Maximum Permissible height above the Elevation of the ARP m</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Up to a distance of 21m</td>
<td>-</td>
</tr>
<tr>
<td>ii)</td>
<td>More than 21m but not exceeding 42m</td>
<td>3</td>
</tr>
<tr>
<td>iii)</td>
<td>More than 42m but not exceeding 63m</td>
<td>6</td>
</tr>
<tr>
<td>iv)</td>
<td>More than 63m but not exceeding 84m</td>
<td>9</td>
</tr>
<tr>
<td>v)</td>
<td>More than 84m but not exceeding 105m</td>
<td>12</td>
</tr>
<tr>
<td>vi)</td>
<td>More than 105m but not exceeding 126m</td>
<td>15</td>
</tr>
<tr>
<td>vii)</td>
<td>More than 126m but not exceeding 147m</td>
<td>18</td>
</tr>
<tr>
<td>viii)</td>
<td>More than 147m but not exceeding 168m</td>
<td>21</td>
</tr>
<tr>
<td>ix)</td>
<td>More than 168m but not exceeding 189m</td>
<td>24</td>
</tr>
<tr>
<td>x)</td>
<td>More than 189m but not exceeding 210m</td>
<td>27</td>
</tr>
<tr>
<td>xi)</td>
<td>More than 210m</td>
<td>30</td>
</tr>
</tbody>
</table>

**A.2.1.1** Table 4.5 gives the height restriction with respect to approach funnels and shall be applicable for the land enclosed in the approach funnels of all runways where distances are measured from each end of the runway, along extended centre line of the runway.

**A.2.1.2** Table 4.6 gives height restriction with respect to transitional area and shall be applicable for the land enclosed in the transitional area of all runways at an aerodrome listed in A-3 where distances are measured from the associated approach funnels, forming the inner boundary of the transitional area and along a line at right angles to the centre line of the runway.

### A-3 AERODROMES

**A-3.1** A list of aerodromes indicating runway directions, runway and elevations and ARP elevations is given in this Code.

### 6.8 MEZZANINES AND EQUIPMENT PLATFORMS

**6.8.1 General.**

Mezzanines shall comply with Clause 6.8.2. Equipment platforms shall comply with Clause 6.8.3.

**6.8.2 Mezzanines.**

A mezzanine or mezzanines in compliance with Clause 6.8.2 shall be considered a portion of the storey below. Such mezzanines shall not contribute to either the building area or number of stories as regulated by Clause 6.3.1. The area of the mezzanine shall be included in determining the fire area. The clear height above and below the mezzanine floor construction shall be not less than 2134 mm (7 feet).

**6.8.2.1 Area limitation.**

The aggregate area of a mezzanine or mezzanines within a room shall be not greater than one-third of the floor area of that room or space in which they are located. The enclosed portion of a room shall not be included in a determination of the floor area of the room in which the mezzanine is located. In determining the allowable mezzanine area, the area of the mezzanine shall not be included in the floor area of the room.

**Exceptions:**

1. The aggregate area of mezzanines in buildings and structures of Type I or II construction for special industrial occupancies in accordance with Clause 6.3.1.1 shall be not
greater than two-thirds of the floor area of the room.

2. The aggregate area of mezzanines in buildings and structures of Type I or II construction shall be not greater than one-half of the floor area of the room in buildings and structures equipped throughout with an approved automatic sprinkler system in accordance with Clause 10.3.3.1.1 and an approved emergency voice/alarm communication system in accordance with Clause 10.7.5.2.2.

3. The aggregate area of a mezzanine within a dwelling unit that is located in a building equipped throughout with an approved automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 shall not be greater than one-half of the floor area of the room, provided that:

   3.1. Except for enclosed closets and bathrooms, the mezzanine shall be open to the room in which such mezzanine is located;

   3.2. The opening to the room shall be unobstructed except for walls not more than 1067 mm (42 inches) in height, columns and posts; and

   3.3. Exceptions to Clause 6.8.2.3 shall not be permitted.

6.8.2.1.1 Aggregate area of mezzanines and equipment platforms.

Where a room contains both a mezzanine and an equipment platform, the aggregate area of the two raised floor levels shall be not greater than two-thirds of the floor area of that room or space in which they are located. The area of the mezzanine shall not exceed the area determined in accordance with Clause 6.8.2.1.

6.8.2.2 Means of escape.

The means of escape for mezzanines shall comply with the applicable provisions of Part 11.

6.8.2.3 Openness.

A mezzanine shall be open and unobstructed to the room in which such mezzanine is located except for walls not more than 1067 mm (42 inches) in height, columns and posts.

Exceptions:

1. Mezzanines or portions thereof are not required to be open to the room in which the mezzanines are located, provided that the occupant load of the aggregate area of the enclosed space is not greater than 10.

2. A mezzanine having two or more exits or access to exits is not required to be open to the room in which the mezzanine is located.

3. Mezzanines or portions thereof are not required to be open to the room in which the mezzanines are located, provided that the aggregate floor area of the enclosed space is not greater than 10 percent of the mezzanine area.

4. In industrial facilities, mezzanines used for control equipment are permitted to be glazed on all sides.

5. In occupancies other than Groups H and I, which are no more than two stories above grade plane and equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, a mezzanine having two or more exits or access to exits shall not be required to be open to the room in which the mezzanine is located.

6.8.3 Equipment platforms.

Equipment platforms in buildings shall not be considered as a portion of the floor below. Such equipment platforms shall not contribute to either the building area or the number of stories.
6.8.3.1 Area limitation.

The aggregate area of all equipment platforms within a room shall be not greater than two-thirds of the area of the room in which they are located. Where an equipment platform is located in the same room as a mezzanine, the area of the mezzanine shall be determined by Clause 6.8.2.1 and the combined aggregate area of the equipment platforms and mezzanines shall be not greater than two-thirds of the room in which they are located. The area of the mezzanine shall not exceed the area determined in accordance with Clause 6.8.2.1.

6.8.3.2 Automatic sprinkler system.

Where located in a building that is required to be protected by an automatic sprinkler system, equipment platforms shall be fully protected by sprinklers above and below the platform, where required by the standards referenced in Clause 10.3.3.

6.8.3.3 Guards.

Equipment platforms shall have guards where required by Clause 11.15.2.

6.9 BUILDING AREA

6.9.1 General.

The floor area of a building shall be determined based on the type of construction, occupancy classification, whether there is an automatic sprinkler system installed throughout the building and the amount of building frontage on public way or open space.

6.9.1.1 Unlimited area buildings.

Unlimited area buildings shall be designed in accordance with Clause 6.10.

6.9.1.2 Special provisions.

The special provisions of Clause 6.13 permit the use of special conditions that are exempt from, or modify, the specific requirements of this part regarding the allowable areas of buildings based on the occupancy classification and type of construction, provided the special condition complies with the provisions specified in Clause 6.13.

6.9.1.3 Basements.

Basements need not be included in the total allowable floor area of a building provided the total area of such basements does not exceed the area permitted for a one-storey above grade plane building.

6.9.2 Allowable area determination.

The allowable area of a building shall be determined in accordance with the applicable provisions of Clause 6.9.2.1 through 6.9.2.4 and clause 6.9.3.

**TABLE 6.9.2**

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UL = Unlimited; NP = Not Permitted; NS = Buildings not equipped throughout with an automatic sprinkler system; S1 = Buildings a maximum of one storey above grade plane equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1; SM = Buildings two or more stories above grade plane equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1; S13R = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.2; S13D = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.3.

a. See Parts 4 and 5 for specific exceptions to the allowable height in this part.
b. See Clause 10.3.2 for the minimum thresholds for protection by an automatic sprinkler system for specific occupancies.
c. New Group H occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.
d. The NS value is only for use in evaluation of existing building area in accordance with the International Existing Building Code.
e. New Group I-1 and I-3 occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.6. For new Group I-1 occupancies, Condition 1, see Exception 1 of Clause 10.3.2.6.
f. New and existing Group I-2 occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.6 and the Ghana Fire Code.
g. New Group I-4 occupancies see Exceptions 2 and 3 of Clause 10.3.2.6.
h. New Group R occupancies are required to be protected by an automatic sprinkler system in accordance with Clause 10.3.2.8.
i. The maximum allowable area for a single-storey nonsprinklered Group U greenhouse is permitted to be 9,000 square feet, or the allowable area shall be permitted to comply with Table C102.1 of Appendix C.

6.9.2.1 Single-occupancy, one-storey buildings.

The allowable area of a single-occupancy building with no more than one storey above grade plane shall be determined in accordance with Equation 6-1:

\[
A_a = A_t + (\text{NS} \times I_f)
\]

* (Equation 6-1)

Where:

\[A_a\] = Allowable area (square feet).
\[A_t\] = Tabular allowable area factor (NS, S1, S13R or S13D value, as applicable) in accordance with Table 6.9.2.
\[\text{NS}\] = Tabular allowable area factor in accordance with Table 6.9.2 for nonsprinklered building (regardless of whether the building is sprinklered).
\[I_f\] = Area factor increase due to frontage (percent) as calculated in accordance with Clause 6.9.3.

6.9.2.2 Mixed-occupancy, one-storey buildings.

The allowable area of a mixed-occupancy building with no more than one storey above grade plane shall be determined in accordance with the applicable provisions of Clause 6.11.1 based on Equation 6-1 for each applicable occupancy.

6.9.2.2.1 Group H-2 or H-3 mixed occupancies.

For a building containing Group H-2 or H-3 occupancies, the allowable area shall be determined in accordance with Clause 6.11.4.2, with the sprinkler system increase applicable only to the portions of the building not classified as Group H-2 or H-3.

6.9.2.3 Single-occupancy, multistorey buildings.

The allowable area of a single-occupancy building with more than one storey above grade plane shall be determined in accordance with Equation 6-2:

\[
A_a = [A_t + (\text{NS} \times I_f) \times S_a]
\]

* (Equation 6-2)

Where:

\[A_a\] = Allowable area (square feet).
\[A_t\] = Tabular allowable area factor (NS, S13R, S13D or SM value, as applicable) in accordance with Table 6.9.2.
\[\text{NS}\] = Tabular allowable area factor in accordance with Table 6.9.2 for nonsprinklered building (regardless of whether the building is sprinklered).
\[I_f\] = Area factor increase due to frontage (percent) as calculated in accordance with Clause 6.9.3.
\[S_a\] = Actual number of building stories above grade plane.

No individual storey shall exceed the allowable area (\(A_a\)) as determined by Equation 6-2 using the value of \(S_a = 1\).

6.9.2.4 Mixed-occupancy, multistorey buildings.

Each storey of a mixed-occupancy building with more than one storey above grade plane shall individually comply with the applicable
requirements of Clause 6.11.1. For buildings with more than three stories above grade plane, the total building area shall be such that the aggregate sum of the ratios of the actual area of each storey divided by the allowable area of such stories, determined in accordance with Equation 5-3 based on the applicable provisions of Clause 6.11.1, shall not exceed three.

$$A_r = [A_a + (NS 	imes I_f)]$$
(Equation 6-3)

Where:
- $A_a$ = Allowable area (square feet).
- $A_t$ = Tabular allowable area factor (NS, S13R, S13D or SM value, as applicable) in accordance with Table 6.92 for a nonsprinklered building (regardless of whether the building is sprinklered).
- $NS$ = Tabular allowable area factor in accordance with Table 6.92 for a nonsprinklered building (regardless of whether the building is sprinklered).
- $I_f$ = Area factor increase due to frontage (percent) as calculated in accordance with Clause 6.93.

Exception: For buildings designed as separated occupancies under Clause 6.11.4 and equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.33.1.2, the total building area shall be such that the aggregate sum of the ratios of the actual area of each storey divided by the allowable area of such stories determined in accordance with Equation 6-3 based on the applicable provisions of Clause 6.11.1, shall not exceed four.

### 6.9.3 Frontage increase.

Every building shall adjoin or have access to a public way to receive an area factor increase based on frontage. Area factor increase shall be determined in accordance with Clauses 6.93.1 through 6.93.3.

#### 6.9.3.1 Minimum percentage of perimeter.

To qualify for an area factor increase based on frontage, a building shall have not less than 25 percent of its perimeter on a public way or open space. Such open space shall be either on the same plot or dedicated for public use and shall be accessed from a street or approved fire lane.

#### 6.9.3.2 Minimum frontage distance.

To qualify for an area factor increase based on frontage, the public way or open space adjacent to the building perimeter shall have a minimum distance ($W$) of 20 feet (6096 mm) cleared of any obstructions from the building face to any of the following:

1. The closest interior line of a street, alley or public way.
2. The exterior face of an adjacent building on the same property.
3. The exterior face of an adjacent building on the same property.

Where the value of $W$ is greater than 9144 mm (30 feet), a value of 9144 mm (30 feet) shall be used in calculating the building area increase based on frontage, regardless of the actual width of the public way or open space. Where the value of $W$ varies along the perimeter of the building, the calculation performed in accordance with Equation 6-5 shall be based on the weighted average calculated in accordance with Equation 6-4.

$$W = (L_1 \times w_1 + L_2 \times w_2 + \ldots + L_n \times w_n)F$$
(Equation 6-4)

Where:
- $W$ = (Width: weighted average) = Calculated width of perimeter.
- $L_n$ = Length of a portion of the exterior perimeter wall.
- $w_n$ = Width (≥20 feet) of a public way or open space adjacent to the exterior perimeter wall.
- $F$ = Building perimeter that fronts on a public way or other open space (20 feet) or more.

Exception: Where a building meets the requirements of Clause 6.10, as applicable, except for compliance with the minimum 18 288 mm (60-foot) public way or yard requirement, and the value of $W$ is greater than 9144 mm (30 feet), the value of $W$ shall not exceed 18 288 mm (60 feet).
6.9.3.3 Amount of increase.

The area factor increase based on frontage shall be determined in accordance with Equation 6-5:

\[ I_f = \frac{[F/P - 0.25]W}{30} \]

6.10 UNLIMITED AREA BUILDINGS

6.10.1 General.

The area of buildings of the occupancies and configurations specified in Clauses 6.10.1 through 6.10.13 shall not be limited. Basements not more than one storey below grade plane shall be permitted.

6.10.1.1 Accessory occupancies.

Accessory occupancies shall be permitted in unlimited area buildings in accordance with the provisions of Clause 6.11.2, otherwise the requirements of Clause 6.10.3 through 6.10.13 shall be applied, where applicable.

6.10.2 Measurement of open spaces.

Where Clause 6.10.3 through 6.10.13 requires buildings to be surrounded and adjoined by public ways and yards, those open spaces shall be determined as follows:

1. Yards shall be measured from the building perimeter in all directions to the closest interior plot lines or to the exterior face of an opposing building located on the same plot, as applicable.

2. Where the building fronts on a public way, the entire width of the public way shall be used.

6.10.2.1 Reduced open space.

The public ways or yards of 18 288 mm (60 feet) in width required in Clauses 6.10.3, 6.10.4, 6.10.5, 6.10.6 and 6.10.12 shall be permitted to be reduced to not less than 12 192 mm (40 feet) in width provided all of the following requirements are met:

1. The reduced width shall not be allowed for more than 75 percent of the perimeter of the building.

2. The exterior walls facing the reduced width shall have a fire-resistance rating of not less than 3 hours.

3. Openings in the exterior walls facing the reduced width shall have opening protectives with a fire protection rating of not less than 3 hours.

6.10.3 Nonsprinklered, one-storey buildings.

The area of a Group F-2 or S-2 building not more than one storey in height shall not be limited where the building is surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.

6.10.4 Sprinklered, one-storey buildings.

The area of a Group A-4 building not more than one storey above grade plane of other than Type V construction, or the area of a Group B, F, M or S building not more than one storey above grade plane of any construction type, shall not be limited where the building is provided with an automatic sprinkler system throughout in accordance with Clause 10.33.1.1 and is surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.

Exceptions:

1. Buildings and structures of Type I or II construction for rack storage facilities that do not have access by the public shall not be limited in height, provided that such buildings conform to the requirements of Clauses 6.10.4 and 10.33.1.1 and the Ghana Fire Code.

2. The automatic sprinkler system shall not be required in areas occupied for indoor participant sports, such as tennis, skating, swimming and equestrian activities in occupancies in Group A-4,
provided that all of the following criteria are met:

2.1. Exit doors directly to the outside are provided for occupants of the participant sports areas.

2.2. The building is equipped with a fire alarm system with manual fire alarm boxes installed in accordance with Clause 10.7.

2.3. An automatic sprinkler system is provided in storage rooms, press boxes, concession booths or other spaces ancillary to the sport activity space.

6.10.4.1 Mixed occupancy buildings with Groups A-1 and A-2.

Group A-1 and A-2 occupancies of other than Type IV construction shall be permitted within mixed occupancy buildings of unlimited area complying with Clause 6.10.4, provided all of the following criteria are met:

1. Group A-1 and A-2 occupancies are separated from other occupancies as required for separated occupancies in Clause 6.11.4.4 with no reduction allowed in the fire-resistance rating of the separation based upon the installation of an automatic sprinkler system.

2. Each area of the portions of the building used for Group A-1 or A-2 occupancies shall not exceed the maximum allowable area permitted for such occupancies in Clause 6.3.1.

3. Exit doors from Group A-1 and A-2 occupancies shall discharge directly to the exterior of the building.

6.10.5 Two-storey buildings.

The area of a Group B, F, M or S building not more than two stories above grade plane shall not be limited where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.33.1.1 and is surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.

6.10.6 Group A-3 buildings of Type II construction.

The area of a Group A-3 building not more than one storey above grade plane, used as a place of religious worship, community hall, dance hall, exhibition hall, gymnasium, lecture hall, indoor swimming pool or tennis court of Type II construction, shall not be limited provided all of the following criteria are met:

1. The building shall not have a stage other than a platform.

2. The building shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.33.1.1.

3. The building shall be surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.

6.10.7 Group A-3 buildings of Type III and IV construction.

The area of a Group A-3 building of Type III or IV construction, with not more than one storey above grade plane and used as a place of religious worship, community hall, dance hall, exhibition hall, gymnasium, lecture hall, indoor swimming pool or tennis court, shall not be limited provided all of the following criteria are met:

1. The building shall not have a stage other than a platform.

2. The building shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.33.1.1.

3. The assembly floor shall be located at or within 533 mm (21 inches) of street or grade level and all exits are provided with ramps complying with Clause 11.12 to the street or grade level.

4. The building shall be surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.
6.10.8 Group H-2, H-3 and H-4 occupancies.

Group H-2, H-3 and H-4 occupancies shall be permitted in unlimited area buildings containing Group F or S occupancies in accordance with Clauses 6.10.4 and 6.10.5 and the provisions of Clauses 6.10.8.1 through 6.10.8.4.

6.10.8.1 Allowable area.

The aggregate floor area of Group H occupancies located in an unlimited area building shall not exceed 10 percent of the area of the building or the area limitations for the Group H occupancies as specified in Clause 6.9 based on the perimeter of each Group H floor area that fronts on a public way or open space.

6.10.8.1.1 Located within the building.

The aggregate floor area of Group H occupancies not located at the perimeter of the building shall not exceed 25 percent of the area limitations for the Group H occupancies as specified in Clause 6.9.

6.10.8.1.1.1 Liquid use, dispensing and mixing rooms.

Liquid use, dispensing and mixing rooms having a floor area of not more than 46.5 m² (500 square feet) need not be located on the outer perimeter of the building where they are in accordance with the Ghana Fire Code.

6.10.8.1.2 Liquid storage rooms.

Liquid storage rooms having a floor area of not more than 93 m² (1,000 square feet) need not be located on the outer perimeter where they are in accordance with the Ghana Fire Code.

6.10.8.1.3 Spray paint booths.

Spray paint booths that comply with the Ghana Fire Code need not be located on the outer perimeter.

6.10.8.2 Located on building perimeter.

Except as provided for in Clause 6.10.8.1.1, Group H occupancies shall be located on the perimeter of the building. In Group H-2 and H-3 occupancies, not less than 25 percent of the perimeter of such occupancies shall be an exterior wall.

6.10.8.3 Occupancy separations.

Group H occupancies shall be separated from the remainder of the unlimited area building and from each other in accordance with Table 6.11.4.

6.10.8.4 Height limitations.

For two-storey, unlimited area buildings, Group H occupancies shall not be located more than one storey above grade plane unless permitted based on the allowable height and number of stories and feet as specified in Clause 6.4 based on the type of construction of the unlimited area building.

6.10.9 Unlimited mixed occupancy buildings with Group H-5.

The area of a Group B, F, H-5, M or S building not more than two stories above grade plane shall not be limited where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.33.1.1, and is surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width, provided all of the following criteria are met:

1. Buildings containing Group H-5 occupancy shall be of Type I or II construction.

2. Each area used for Group H-5 occupancy shall be separated from other occupancies as required in Clause 4.15.11 and 6.11.4.

3. Each area used for Group H-5 occupancy shall not exceed the maximum allowable area permitted for such occupancies in Clause 6.3.1 including modifications of Clause 6.9

Exception: Where the Group H-5 occupancy exceeds the maximum allowable area, the Group H-5 shall be subdivided into areas that are separated by 2-hour fire barriers.

6.10.10 Aircraft paint hangar.

The area of a Group H-2 aircraft paint hangar not more than one storey above grade plane shall not be limited where such aircraft paint hangar complies with the provisions of Clause
4.12.5 and is surrounded and adjoined by public ways or yards not less in width than one and one-half times the building height.

6.10.11 Group E buildings.

The area of a Group E building not more than one storey above grade plane, of Type II, IIIA or IV construction, shall not be limited provided all of the following criteria are met:

1. Each classroom shall have not less than two means of escape, with one of the means of escape being a direct exit to the outside of the building complying with Clause 11.22.
2. The building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.33.1.1.
3. The building is surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.

6.10.12 Motion picture theaters.

In buildings of Type II construction, the area of a motion picture theater located on the first storey above grade plane shall not be limited where the building is provided with an automatic sprinkler system throughout in accordance with Clause 10.33.1.1 and is surrounded and adjoined by public ways or yards not less than 18 288 mm (60 feet) in width.

6.10.13 Covered and open mall buildings and anchor buildings.

The area of covered and open mall buildings and anchor buildings not exceeding three stories in height that comply with Clause 4.2 shall not be limited.

6.11 MIXED USE AND OCCUPANCY

6.11.1 General.

Each portion of a building shall be individually classified in accordance with Clause 3.2.1. Where a building contains more than one occupancy group, the building or portion thereof shall comply with the applicable provisions of Clause 6.11.2, 6.11.3 or 6.11.4, or a combination of these clauses.

Exceptions:

1. Occupancies separated in accordance with Clause 6.13.
2. Where required by Table 4.15.6.2, areas of Group H-1, H-2 and H-3 occupancies shall be located in a detached building or structure.
3. Uses within live/work units, complying with Clause 4.19, are not considered separate occupancies.

6.11.2 Accessory occupancies.

Accessory occupancies are those occupancies that are ancillary to the main occupancy of the building or portion thereof. Accessory occupancies shall comply with the provisions of Clauses 6.11.2.1 through 6.11.2.4.

6.11.2.1 Occupancy classification.

Accessory occupancies shall be individually classified in accordance with Clause 3.2.1. The requirements of this Code shall apply to each portion of the building based on the occupancy classification of that space.

6.11.2.2 Allowable building height.

The allowable height and number of stories of the building containing accessory occupancies shall be in accordance with Clause 6.4 for the main occupancy of the building.

6.11.2.3 Allowable building area.

The allowable area of the building shall be based on the applicable provisions of Clause 6.9 for the main occupancy of the building. Aggregate accessory occupancies shall not occupy more than 10 percent of the floor area of the storey in which they are located and shall not exceed the tabular values for nonsprinklered buildings in Table 6.92 for each such accessory occupancy.

6.11.2.4 Separation of occupancies.

No separation is required between accessory occupancies and the main occupancy.

Exceptions:
1. Group H-2, H-3, H-4 and H-5 occupancies shall be separated from all other occupancies in accordance with Clause 508.4.

2. Group I-1, R-1, R-2 and R-3 dwelling units and sleeping units shall be separated from other dwelling or sleeping units and from accessory occupancies contiguous to them in accordance with the requirements of Clause 4.20.

6.11.3 Nonseparated occupancies.

Buildings or portions of buildings that comply with the provisions of this clause shall be considered as nonseparated occupancies.

6.11.3.1 Occupancy classification.

Nonseparated occupancies shall be individually classified in accordance with Clause 3.2.1. The requirements of this Code shall apply to each portion of the building based on the occupancy classification of that space. In addition, the most restrictive provisions of Part 10 that apply to the nonseparated occupancies shall apply to the total nonseparated occupancy area.

6.11.3.1.1 High-rise buildings.

Where nonseparated occupancies occur in a high-rise building, the most restrictive requirements of Clause 4.3 that apply to the nonseparated occupancies shall apply throughout the high-rise building.

6.11.3.2 Group I-2, Condition 2 occupancies.

Where one of the nonseparated occupancies is Group I-2, Condition 2, the most restrictive requirements of Clause 4.7 and 6.12 and 8.12 shall apply throughout the fire area containing the Group I-2 occupancy. The most restrictive requirements of Part 11 shall apply to the path of escape from the Group I-2, Condition 2 occupancy up to and including the exit discharge.

6.11.3.2 Allowable building area, height and number of stories.

The allowable building area, height and number of stories of the building or portion thereof shall be based on the most restrictive allowances for the occupancy groups under consideration for the type of construction of the building in accordance with Clause 5.3.1.

6.11.3.3 Separation.

No separation is required between nonseparated occupancies.

Exceptions:

1. Group H-2, H-3, H-4 and H-5 occupancies shall be separated from all other occupancies in accordance with Clause 6.11.4.

2. Group I-1, R-1, R-2 and R-3 dwelling units and sleeping units shall be separated from other dwelling or sleeping units and from other occupancies contiguous to them in accordance with the requirements of Clause 4.20.

6.11.4 Separated occupancies.

Buildings or portions of buildings that comply with the provisions of this clause shall be considered as separated occupancies.
TABLE 6.11.4
REQUIRED SEPARATION OF OCCUPANCIES (HOURS)\(^1\)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>NS</td>
<td>S</td>
<td>NS</td>
<td>S</td>
<td>NS</td>
<td>S</td>
<td>NS</td>
<td>NS</td>
<td>S</td>
<td>NS</td>
</tr>
<tr>
<td>A, E, I-1, I-3, I-4</td>
<td>N</td>
<td>N</td>
<td>2</td>
<td>2</td>
<td>NP</td>
<td>1</td>
<td>2</td>
<td>N</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>H-1</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>H-2</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-3, H-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-5</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.33.1.1.
NS = Buildings not equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.33.1.1.
N = No separation requirement.
NP = Not Required.

6.11.4.1 Occupancy classification.

Separated occupancies shall be individually classified in accordance with Clause 3.2.1. Each separated space shall comply with this Code based on the occupancy classification of that portion of the building. The most restrictive provisions of Part 10 that apply to the separate occupancies shall apply to the total nonfire-barrier-separated occupancy area. Occupancy separations that serve to define fire area limits established in Part 10 for requiring fire protection systems shall also comply with this Code.

6.11.4.3 Allowable building height and number of stories.

Each separated occupancy shall comply with the building height limitations and storey limitations based on the type of construction of the building in accordance with Clause 6.3.1.

**Exception:** Special provisions of Clause 6.13 shall permit occupancies at building heights and number of stories other than provided in Clause 6.3.1.

6.11.4.4 Separation.

Individual occupancies shall be separated from adjacent occupancies in accordance with Table 6.11.4.

6.11.4.4.1 Construction.

Required separations shall be fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both, so as to completely separate adjacent occupancies.
6.12 INCIDENTAL USES

6.12.1 General
Incidental uses located within single occupancy or mixed occupancy buildings shall comply with the provisions of this clause. Incidental uses are ancillary functions associated with a given occupancy that generally pose a greater level of risk to that occupancy and are limited to those uses listed in Table 6.12.

Exception: Incidental uses within and serving a dwelling unit are not required to comply with this clause.

6.12.2 Occupancy classification.
Incidental uses shall not be individually classified in accordance with Clause 3.2.1. Incidental uses shall be included in the building occupancies within which they are located.

6.12.3 Area limitations.
Incidental uses shall not occupy more than 10 percent of the building area of the storey in which they are located.

6.12.4 Separation and protection.
The incidental uses listed in Table 6.12 shall be separated from the remainder of the building or equipped with an automatic sprinkler system, or both, in accordance with the provisions of that table.

6.12.4.1 Separation.
Where Table 6.12 specifies a fire-resistance-rated separation, the incidental uses shall be separated from the remainder of the building by a fire barrier constructed in accordance with Clause 8.7 or a horizontal assembly constructed in accordance with Clause 8.11, or both. Construction supporting 1-hour fire barriers or horizontal assemblies used for incidental use separations in buildings of Type IB, IIB and IVB construction is not required to be fire-resistance rated unless required by other clauses of this Code.

6.12.4.2 Protection.
Where Table 6.12 permits an automatic sprinkler system without a fire barrier, the incidental uses shall be separated from the

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**TABLE 6.12: INCIDENTAL USES**

<table>
<thead>
<tr>
<th>ROOM OR AREA</th>
<th>SEPARATION AND/OR PROTECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace room where any piece of equipment is over 400,000 Btu per hour input</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>Rooms with boilers where the largest piece of equipment is over 15 psi and 10 horsepower</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>Refrigeration machinery room</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>Hydrogen fuel gas rooms, not classified as Group H</td>
<td>1 hour in Group B, F, M, S and U occupancies; 2 hours in Group A, E, I and R occupancies.</td>
</tr>
<tr>
<td>Incinerator rooms</td>
<td>2 hours and provide automatic sprinkler system</td>
</tr>
<tr>
<td>Paint shops, not classified as Group H, located in occupancies other than Group F</td>
<td>2 hours; or 1 hour and provide automatic sprinkler system</td>
</tr>
<tr>
<td>In Group E occupancies, laboratories and vocational shops not classified as Group H</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>In Group I-2 occupancies, laboratories not classified as Group H</td>
<td>1 hour and provide automatic sprinkler system</td>
</tr>
<tr>
<td>In ambulatory care facilities, laboratories not classified as Group H</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>Laundry rooms over 100 square feet</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>In Group I-2, laundry rooms over 100 square feet</td>
<td>1 hour</td>
</tr>
<tr>
<td>Group I-3 cells and Group I-2 patient rooms equipped with padded surfaces</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>In Group I-2, physical plant maintenance shops</td>
<td>1 hour</td>
</tr>
<tr>
<td>In ambulatory care facilities or Group I-2 occupancies, waste and linen collection rooms with containers that have an aggregate volume of 10 cubic feet or greater</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>In other than ambulatory care facilities and Group I-2 occupancies, waste and linen collection rooms over 100 square feet</td>
<td>1 hour or provide automatic sprinkler system</td>
</tr>
<tr>
<td>In ambulatory care facilities or Group I-2 occupancies, storage rooms greater than 100 square feet</td>
<td>1 hour</td>
</tr>
<tr>
<td>Stationary storage battery systems having an energy capacity greater than the threshold quantity specified in Table 1206.2 of the International Fire Code</td>
<td>1 hour in Group B, F, M, S and U occupancies; 2 hours in Group A, E, I and R occupancies.</td>
</tr>
<tr>
<td>Electrical installations and transformers</td>
<td>See Sections 110.26 through 110.34 and Sections 450.8 through 450.48 of NFPA 70 for protection and separation requirements.</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.0929 m², 1 pound per square inch (psi) = 6.9 kPa, 1 British thermal unit (Btu) per hour = 0.293 watts, 1 horsepower = 746 watts, 1 gallon = 3.785 L, 1 cubic foot = 0.0283 m³.
remainder of the building by construction capable of resisting the passage of smoke. The walls shall extend from the top of the foundation or floor assembly below to the underside of the ceiling that is a component of a fire-resistance-rated floor assembly or roof assembly above or to the underside of the floor or roof sheathing, deck or slab above. Doors shall be self- or automatic-closing upon detection of smoke in accordance with Clause 8.16.2.6.6. Doors shall not have air transfer openings and shall not be undercut in excess of the clearance permitted in accordance with the Ghana Fire Code. Walls surrounding the incidental use shall not have air transfer openings unless provided with smoke dampers in accordance with Clause 8.10.8.

6.12.4.2.1 Protection limitation.
Where an automatic sprinkler system is provided in accordance with Table 6.12, only the space occupied by the incidental use need be equipped with such a system.

6.13 SPECIAL PROVISIONS

6.13.1 General.
The provisions in Clauses 6.13.2 through 6.13.9 shall permit the use of special conditions that are exempt from, or modify, the specific requirements of this part regarding the allowable building heights and areas of buildings based on the occupancy classification and type of construction, provided the special condition complies with the provisions specified in this clause for such condition and other applicable requirements of this Code. The provisions of Clauses 6.13.2 through 6.13.8 are to be considered independent and separate from each other.

6.13.2 Horizontal building separation allowance.
A building shall be considered as separate and distinct buildings for the purpose of determining area limitations, continuity of fire walls, limitation of number of stories and type of construction where all of the following conditions are met:

1. The buildings are separated with a horizontal assembly having a fire-resistance rating of not less than 3 hours. Where vertical offsets are provided as part of a horizontal assembly, the vertical offset and the structure supporting the vertical offset shall have a fire-resistance rating of not less than 3 hours.

2. The building below, including the horizontal assembly, is of Type IA construction.

3. Shaft, stairway, ramp and escalator enclosures through the horizontal assembly shall have not less than a 2-hour fire-resistance rating with opening protective in accordance with Clause 8.16.

Exception: Where the enclosure walls below the horizontal assembly have not less than a 3-hour fire-resistance rating with opening protective in accordance with Clause 8.16, the enclosure walls extending above the horizontal assembly shall be permitted to have a 1-hour fire-resistance rating, provided:

1. The building above the horizontal assembly is not required to be of Type I construction;

2. The enclosure connects fewer than four stories; and

3. The enclosure opening protective above the horizontal assembly have a fire protection rating of not less than 1 hour.

4. The building or buildings above the horizontal assembly shall be permitted to have multiple Group A occupancy uses, each with an occupant load of less 300, or Group B, M, R or S occupancies.

5. The building below the horizontal assembly shall be protected throughout by an approved automatic sprinkler system in accordance with Clause 10.33.1.1, and shall be permitted to be any occupancy allowed by this Code except Group H.

6. The maximum building height in mm (feet) shall not exceed the limits set forth in Clause 6.4.3 for the building having the smaller allowable height as measured from the grade plane.
6.13.3 Group S-2 enclosed parking garage with Group S-2 open parking garage above.

A Group S-2 enclosed parking garage with not more than one storey above grade plane and located below a Group S-2 open parking garage shall be classified as a separate and distinct building for the purpose of determining the type of construction where all of the following conditions are met:

1. The allowable area of the building shall be such that the sum of the ratios of the actual area divided by the allowable area for each separate occupancy shall not exceed 1.

2. The Group S-2 enclosed parking garage is of Type I or II construction and is at least equal to the fire-resistance requirements of the Group S-2 open parking garage.

3. The height and the number of tiers of the Group S-2 open parking garage shall be limited as specified in Table 4.6.5.4.

4. The floor assembly separating the Group S-2 enclosed parking garage and Group S-2 open parking garage shall be protected as required for the floor assembly of the Group S-2 enclosed parking garage. Openings between the Group S-2 enclosed parking garage and Group S-2 open parking garage, except exit openings, shall not be required to be protected.

5. The Group S-2 enclosed parking garage is used exclusively for the parking or storage of private motor vehicles, but shall be permitted to contain an office, waiting room and toilet room having a total area of not more than $93 \text{ m}^2$ (1,000 square feet) and mechanical equipment rooms incidental to the operation of the building.

6.13.4 Parking beneath Group R.

Where a maximum one storey above grade plane Group S-2 parking garage, enclosed or open, or combination thereof, of Type I construction or open of Type IV construction, with grade entrance, is provided under a building of Group R, the number of stories to be used in determining the minimum type of construction shall be measured from the floor above such a parking area. The floor assembly between the parking garage and the Group R above shall comply with the type of construction required for the parking garage and shall also provide a fire-resistance rating not less than the mixed occupancy separation required in Clause 6.11.4.

6.13.5 Group R-1 and R-2 buildings of Type IIIA construction.

The height limitation for buildings of Type IIIA construction in Groups R-1 and R-2 shall be increased to six stories and 22,860 mm (75 feet) where the first floor assembly above the basement has a fire-resistance rating of not less than 3 hours and the floor area is subdivided by 2-hour fire-resistance-rated fire walls into areas of not more than 279 m² (3,000 square feet).

6.13.6 Group R-1 and R-2 buildings of Type IIA construction.

The height limitation for buildings of Type IIA construction in Groups R-1 and R-2 shall be increased to nine stories and 30,480 mm (100 feet) where the building is separated by not less than 15,240 mm (50 feet) from any other building on the plot and from plot lines, the exits are segregated in an area enclosed by a 2-hour fire-resistance-rated fire wall and the first floor assembly has a fire-resistance rating of not less than $1\frac{1}{2}$ hours.

6.13.7 Open parking garage beneath Groups A, I, B, M and R.

Open parking garages constructed under Groups A, I, B, M and R shall not exceed the height and area limitations permitted under Clause 4.6.5. The height and area of the portion of the building above the open parking garage shall not exceed the limitations in Clause 6.3 for the upper occupancy. The height, in both feet and stories, of the portion of the building above the open parking garage shall be measured from grade plane and shall include both the open parking garage and the portion of the building above the parking garage.
6.13.7.1 Fire separation.

Fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11 between the parking occupancy and the upper occupancy shall correspond to the required fire-resistance rating prescribed in Table 6.11.4 for the uses involved. The type of construction shall apply to each occupancy individually, except that structural members, including main bracing within the open parking structure, which is necessary to support the upper occupancy, shall be protected with the more restrictive fire-resistance-rated assemblies of the groups involved as shown in Table 7.1. Means of escape for the upper occupancy shall conform to Part 11 and shall be separated from the parking occupancy by fire barriers having not less than a 2-hour fire-resistance rating as required by Clause 8.7 with self-closing doors complying with Clause 8.16 or horizontal assemblies having not less than a 2-hour fire-resistance rating as required by Clause 8.11, with self-closing doors complying with Clause 8.16. Means of escape from the open parking garage shall comply with Clause 4.6.5.

6.13.8 Group B or M buildings with Group S-2 open parking garage above.

Group B or M occupancies located below a Group S-2 open parking garage of a lesser type of construction shall be considered as a separate and distinct building from the Group S-2 open parking garage for the purpose of determining the type of construction where all of the following conditions are met:

1. The buildings are separated with a horizontal assembly having a fire-resistance rating of not less than 2 hours.

2. The occupancies in the building below the horizontal assembly are limited to Groups B and M.

3. The occupancy above the horizontal assembly is limited to a Group S-2 open parking garage.

4. The building below the horizontal assembly is of Type IA construction.

Exception: The building below the horizontal assembly shall be permitted to be of Type IB or II construction, but not less than the type of construction required for the Group S-2 open parking garage above, where the building below is not greater than one storey in height above grade plane.

5. The height and area of the building below the horizontal assembly does not exceed the limits set forth in Clause 6.3.

6. The height and area of the Group S-2 open parking garage does not exceed the limits set forth in Clause 4.6.5. The height, in both feet and stories, of the Group S-2 open parking garage shall be measured from grade plane and shall include the building below the horizontal assembly.

7. Exits serving the Group S-2 open parking garage discharge directly to a street or public way and are separated from the building below the horizontal assembly by 2-hour fire barriers constructed in accordance with Clause 8.7 or 2-hour horizontal assemblies constructed in accordance with Clause 8.11, or both.

6.13.9 Multiple buildings above a horizontal assembly.

Where two or more buildings are provided above the horizontal assembly separating a Group S-2 parking garage or building below from the buildings above in accordance with the special provisions in Clause 6.13.2, 6.13.3 or 6.13.8, the buildings above the horizontal assembly shall be regarded as separate and distinct buildings from each other and shall comply with all other provisions of this Code as applicable to each separate and distinct building.

6.14 ROOM AND SPACE DIMENSIONS

6.14.1 General

This clause applies only to dwelling units that are intended for use on a continuing basis as the principal residence of the occupant.

6.14.1.2 Method of measurement

Unless otherwise indicated herein, the areas, dimensions and heights of rooms or spaces
shall be measured between finished wall surfaces and between finished floor and ceiling surfaces.

6.14.1.3 Combined Space
Minimum dimensions listed for rooms or spaces in combination with other rooms or spaces refer to the minimum dimension of the combined space.

6.14.1.4. Floor areas
Minimum (usable) floor areas specified in this clause do not include closets or built-in bedroom cabinets unless otherwise indicated.

6.14.1.5 Combination rooms
Two or more areas are considered as a combination room if the dividing wall occupies less than 60 percent of the separating plane.

6.14.1.6 Areas and dimensions of rooms and spaces may be less than required in this clause provided it can be shown to the satisfaction of the authority having jurisdiction that the rooms and spaces are adequate for their intended use, such as by the provision of built-in furniture to compensate for reduced sizes.

6.14.2 Ceiling heights

6.14.2.1 Room heights
Heights of rooms or spaces in residential occupancies shall conform to Table 16.4.2.A

<table>
<thead>
<tr>
<th>Room or space</th>
<th>Minimum heights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living room or space, Dining room or space, Kitchen or kitchen space</td>
<td>2.3m over at least 75 percent of the required floor area with a clear height of at least 2.0m at any point over the required area.</td>
</tr>
<tr>
<td>Bedroom or bedroom space</td>
<td>2.3m over at least 50 percent of the required floor area</td>
</tr>
</tbody>
</table>

6.14.2.2 The clear height above and below a mezzanine floor assembly in all occupancies shall not be less than 2.0m unless otherwise permitted by the authority having jurisdiction.

6.14.2.3 The clear height in a storage garage shall not be less than 2.0m.

6.14.3 Living rooms or Spaces within dwelling units

6.14.3.1 Living room area
Living areas within dwelling units, either as separate rooms or in combination with other spaces, shall have at least 13.47m² of floor area and shall have no dimension less than 3m within the required areas. Where the area of a living space is combined with a kitchen and dining area, the living area alone in a bachelor dwelling unit shall be at least 11.15m².

Table 16.4.2.A – Ceiling heights
(Forming part of Article 7.4.2.1)
6.14.4 Dining rooms or spaces within dwelling units

6.14.4.1 A dining space in combination with other space shall have a minimum floor area of 3.25m². Dining rooms not combined with other space shall have a minimum area of 6.50m².

6.14.4.2 Except as permitted in Article 6.14.4.3, a dining room or space combined with other space shall have no dimension less than 2.3m within the required area measured between wall faces or a wall face and a built-in cabinet or appliance.

6.14.4.3 When a required dining area is provided in a kitchen or serves a bachelor dwelling unit, the minimum dimension of such space may be reduced to 1.7m.

6.14.5 Kitchen within dwelling units

6.14.5.1 Kitchen area
Kitchen areas within dwelling units either separate or in combination with other space shall have at least 7.43m² of floor area including the area occupied by the base cabinets, except that in bachelor dwelling units the minimum floor area shall be 3.72m².

6.14.5.2 At least 910mm clearance shall be provided in front of base cabinet, work surfaces, counter tops and appliances.

6.14.6 Bedroom or space in dwelling units

6.14.6.1 Main bedroom area
Except as provided in this Code at least one bedroom in every dwelling unit shall have at least 11.15m² of floor area where built-in cabinets are not provided and 10.10m² of floor area where built-in cabinets are provided. The minimum dimension within their required area shall be 2.7m.

6.14.6.2 Other bedroom areas
Except as provided in this Code additional bedrooms shall have at least 8.36m² of floor area where built-in cabinets are not provided and 7.57m² of floor area where built-in cabinets are provided. The minimum dimension within the required area shall be 2.44m.

6.14.6.3 Combination bedroom areas
Bedroom spaces in combination with other spaces shall have at least 5.05m² of floor area and have no dimension less than 1.98m within the required area.

6.14.7 Bathrooms and water-closet rooms

6.14.7.1 Bathroom areas
In every dwelling unit an enclosed space of a minimum of 3m² shall be provided to accommodate a bathtub or shower bath, water closet and lavatory basin.

6.14.7.2 At least 550mm clearance shall be provided in front of the tub or shower stall to an opposite wall face or 450mm in front to another fixture over at least 600mm length of the bathtub or shower.

6.14.7.3 The centre line of the water closet shall be at least 400mm away from an adjacent side wall and from a vanity. At least 450mm clearance shall be provided in front of the water closet to the opposite wall or another fixture.

6.14.7.4 The centre line of a lavatory basin shall be at least 400mm from an adjacent side wall. At least 550mm clearance shall be provided in front of the lavatory basin to an opposite wall or 450mm clearance in front to another fixture.

6.14.8 Hallways

6.14.8.1 Width of hallways
The width of a hallway within a dwelling unit shall be at least 1200mm.
PART 7: TYPES OF CONSTRUCTION

User note:
About this part: Part 7 establishes four types of construction in which each building must be categorized. This part looks at the materials used in the building (combustible or noncombustible) and the extent to which building elements such as building frame, roof, wall and floor can resist fire. Depending on the type of construction, the specific building element and its proximity to a plot line, fire resistance of 1 to 3 hours is specified.

7.1 GENERAL

7.1.1 Scope.

The provisions of this part shall control the classification of buildings as to type of construction.

The design of any building and types of materials used in its construction are important factors in making the building resistant to a complete burn-out and in preventing the spread of fire, smoke or fumes, which may otherwise contribute to the loss of lives and property. The fire resistance of a building or its structural and non-structural elements is expressed in hours against a specified fire load which is expressed in kcal/m² and against a certain intensity of fire. For the purposes of this Code, the types of construction according to fire resistance shall be classified in four (4) categories:

a) Type 1
b) Type 2
c) Type 3
d) Type 4

The fire resistance ratings for various types of construction for structural and non-structural members are given in Table 7.1A.
Table 7.1A - Fire resistance ratings of structural and non-structural elements (in hours)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Structural Element</th>
<th>Type of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Type 1</td>
</tr>
<tr>
<td>1)</td>
<td>Exterior walls:</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Fire separation less than 3.7 m</td>
<td>Bearing</td>
</tr>
<tr>
<td>b)</td>
<td>Fire separation of 3.7 m or more but less than 9 m</td>
<td>Non-bearing</td>
</tr>
<tr>
<td>c)</td>
<td>Fire separation of 9 m or more</td>
<td>Non-bearing</td>
</tr>
<tr>
<td>2)</td>
<td>Fire resisting walls</td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>Fire separation assemblies (like fire check doors)</td>
<td></td>
</tr>
<tr>
<td>IV)</td>
<td>Fire enclosures of exitways, hallways and stairways</td>
<td></td>
</tr>
<tr>
<td>V)</td>
<td>Shaft other than exitways, elevator and hoistways</td>
<td></td>
</tr>
<tr>
<td>VI)</td>
<td>Exitway access corridors</td>
<td></td>
</tr>
<tr>
<td>VII)</td>
<td>Vertical separation of tenant spaces</td>
<td></td>
</tr>
<tr>
<td>VIII)</td>
<td>Dwelling unit separation</td>
<td></td>
</tr>
<tr>
<td>IX)</td>
<td>Non-load bearing partitions</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Interior bearing walls, bearing partitions, columns, girders, trusses (other than roof trusses) and framing</td>
<td>Supporting more than one floor</td>
</tr>
<tr>
<td>b)</td>
<td>Supporting one floor only</td>
<td>Supporting a roof only</td>
</tr>
<tr>
<td>x)</td>
<td>Structural members support walls</td>
<td></td>
</tr>
<tr>
<td>XI)</td>
<td>Floor construction including walls</td>
<td></td>
</tr>
<tr>
<td>XII)</td>
<td>Roof construction</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>5 m or less in height to lowest member</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>More than 5 m but less than 6.7 m in height to lowest member</td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>6.7 m or more in height to lowest member</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 7.1
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>HT</td>
</tr>
<tr>
<td>Primary structural frame' (see Clause 202)</td>
<td>a,b</td>
<td>2</td>
<td>b</td>
<td>0</td>
<td>HT</td>
</tr>
<tr>
<td>Bearing walls</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Exterior</td>
<td>a</td>
<td>2a</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Interior</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td>See Table 602</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Interior</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Clause 202)</td>
<td>1/b</td>
<td>1/b,c</td>
<td>b,c</td>
<td>c</td>
<td>b,c</td>
</tr>
<tr>
<td>Roof construction and associated secondary members (see Clause 202)</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
  a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
  b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members in roof construction shall not be required, including protection of primary structural frame members, roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
  c. In all occupancies, heavy timber complying with Clause 24.4.11 shall be allowed where a 1-hour or less fire-resistance rating is required.
  d. Not less than the fire-resistance rating required by other clauses of this Code.
  e. Not less than the fire-resistance rating based on fire separation distance (see Table 7.2).
  f. Not less than the fire-resistance rating as referenced in Clause 8.4.10.
7.2 CONSTRUCTION CLASSIFICATION

TABLE 7.2: FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON
FIRE SEPARATION DISTANCEa, d, g

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE X (feet)</th>
<th>TYPE OF CONSTRUCTION</th>
<th>OCCUPANCY GROUP H</th>
<th>OCCUPANCY GROUP F-1, M, S-1</th>
<th>OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U</th>
</tr>
</thead>
<tbody>
<tr>
<td>X &lt; 5</td>
<td>All</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5 ≤ X &lt; 10</td>
<td>IA</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10 ≤ X &lt; 30</td>
<td>IA, IB</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>IVB</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>X ≥ 30</td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.
a. Load-bearing exterior walls shall also comply with the fire-resistance rating requirements of Table 7.1.
b. See Clause 8.6.1.1 for party walls.
c. Open parking garages complying with Clause 4.6 shall not be required to have a fire-resistance rating.
d. The fire-resistance rating of an exterior wall is determined based upon the fire separation distance of the exterior wall and the storey in which the wall is located.
e. For special requirements for Group H occupancies, see Clause 4.15.6.
f. For special requirements for Group S aircraft hangars, see Clause 4.12.3.1.
g. Where Table 8.5.8 permits nonbearing exterior walls with unlimited area of unprotected openings, the required fire-resistance rating for the exterior wall is 0 hours.
h. For a building containing only a Group U occupancy private garage or carport, the exterior wall shall not be required to have a fire-resistance rating where the fire separation distance is 5 feet (1523 mm) or greater.
i. For a Group R-3 building of Type I-B or Type IV-B construction, the exterior wall shall not be required to have a fire-resistance rating where the fire separation distance is 5 feet (1523 mm) or greater.

7.2.1 General.

Buildings and structures erected or to be erected, altered or extended in height or area shall be classified in one of the five construction types defined in Clauses 7.2.2 through 7.2.5. The building elements shall have a fire-resistance rating not less than that specified in Table 7.1 and exterior walls shall have a fire-resistance rating not less than that specified in Table 7.2. Where required to have a fire-resistance rating by Table 7.1, building elements shall comply with the applicable provisions of Clause 7.3.2.

The protection of openings, ducts and air transfer openings in building elements shall not be required unless required by other provisions of this Code.

7.2.1.1 Minimum requirements.

A building or portion thereof shall not be required to conform to the details of a type of construction higher than that type which meets the minimum requirements based on occupancy even though certain features of such a building actually conform to a higher type of construction.

7.2.2 Types I.

Types I construction are those types of construction in which the building elements listed in Table 7.1 are of noncombustible materials, except as permitted in Clause 7.3 and elsewhere in this Code.

7.2.3 Type II.

Type II construction is that type of construction in which the exterior walls are of noncombustible materials and the interior
building elements are of any material permitted by this Code. Fire-retardant-treated wood framing and sheathing complying with Clause 24.3.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less.

7.2.4 Type III.

Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid wood, laminated wood, heavy timber (HT) or structural composite timber (SCL) without concealed spaces. The minimum dimensions for permitted materials including solid timber, glued-laminated timber, structural composite timber (SCL), and cross-laminated timber and details of Type III construction shall comply with the provisions of this clause and Clause 24.4.11. Exterior walls complying with Clause 7.2.4.1 or 7.2.4.2 shall be permitted. Interior walls and partitions not less than 1-hour fire-resistance rating or heavy timber complying with Clause 24.4.11.2.2 shall be permitted.

7.2.4.1 Fire-retardant-treated wood in exterior walls.

Fire-retardant-treated wood framing and sheathing complying with Clause 24.3.2 shall be permitted within exterior wall assemblies not less than 152 mm (6 inches) in thickness with a 2-hour rating or less.

7.2.4.2 Cross-laminated timber in exterior walls.

Cross-laminated timber complying with Clause 24.3.1.4 shall be permitted within exterior wall assemblies not less than 152 mm (6 inches) in thickness with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. Fire-retardant-treated wood sheathing complying with Clause 24.3.2 and not less than 12 mm (15 / 32 inch) thick;
2. Gypsum board not less than 12.7 mm (1 / 2 inch) thick; or
3. A noncombustible material.

7.2.4.3 Exterior structural members.

Where a horizontal separation of 6096 mm (20 feet) or more is provided, wood columns and arches conforming to heavy timber sizes complying with Clause 24.4.11 shall be permitted to be used externally.

7.3 COMBUSTIBLE MATERIAL IN TYPES I AND II CONSTRUCTION

7.3.1 Allowable materials.

Combustible materials shall be permitted in buildings of Type I or II construction in the following applications and in accordance with Clauses 7.3.1.1 through 7.3.1.3:

1. Fire-retardant-treated wood shall be permitted in:
   1.1. Nonbearing partitions where the required fire-resistance rating is 2 hours or less.
   1.2. Nonbearing exterior walls where fire-resistance-rated construction is not required.
   1.3. Roof construction, including girders, trusses, framing and decking.

Exception: In buildings of Type IA construction exceeding two stories above grade plane, fire-retardant-treated wood is not permitted in roof construction where the vertical distance from the upper floor to the roof is less than 6096 mm (20 feet).

1.4. Balconies, porches, decks and exterior stairways not used as required exits on buildings three stories or less above grade plane.

2. Thermal and acoustical insulation, other than foam plastics, having a flame spread index of not more than 25.

Exceptions:
1. Insulation placed between two layers of noncombustible materials without an intervening airspace shall be allowed to have a flame spread index of not more than 100.

2. Insulation installed between a finished floor and solid decking without intervening airspace shall be allowed to have a flame spread index of not more than 200.

3. Foam plastics in accordance with Part 27.

4. Roof coverings that have an A, B or C classification.

5. Interior floor finish and floor covering materials installed in accordance with Clause 8.4.

6. Millwork such as doors, door frames, window sashes and frames.

7. Interior wall and ceiling finishes installed in accordance with Clause 9.3.

8. Trim installed in accordance with Clause 9.6.

9. Where not installed greater than 4572 mm (15 feet) above grade, show windows, nailing or furring strips and wooden bulkheads below show windows, including their frames, aprons and show cases.

10. Finish flooring installed in accordance with Clause 9.5.

11. Partitions dividing portions of stores, offices or similar places occupied by one tenant only and that do not establish a corridor serving an occupant load of 30 or more shall be permitted to be constructed of fire-retardant-treated wood, 1-hour fire-resistance-rated construction or of wood panels or similar light construction up to 1829 mm (6 feet) in height.

12. Stages and platforms constructed in accordance with Clause 4.10.2 and 4.10.3 respectively.

13. Combustible exterior wall coverings, balconies and similar projections and bay or oriel windows in accordance with part 15 and Clause 8.5.2.3.1.

14. Blocking such as for handrails, millwork, cabinets and window and door frames.

15. Light-transmitting plastics as permitted by Part 27.

16. Mastics and caulking materials applied to provide flexible seals between components of exterior wall construction.

17. Exterior plastic veneer installed in accordance with Clause 27.5.2.

18. Nailing or furring strips as permitted by Clause 9.3.15.

19. Heavy timber as permitted by Note c to Table 7.1 and Clauses 7.2.4.3 and 7.5.2.3.1.

20. Aggregates, component materials and admixtures as permitted by Clause 8.3.2.2.

21. Spray-in fire-resistant materials and intumescent and mastic fire-resistant coatings, determined on the basis of fire resistance tests in accordance with Clause 8.3.2 and installed in accordance with Clauses 19.5.14 and 19.5.15), respectively.

22. Materials used to protect penetrations in fire-resistance-rated assemblies in accordance with Clause 8.14.

23. Materials used to protect joints in fire-resistance-rated assemblies in accordance with Clause 8.15.

of Types I construction in accordance with Clause 8.18.5.

25. Materials exposed within plenums complying with Clause 7.2 of this Code.

26. Wall construction of freezers and coolers of less than 92.9 m² (1,000 square feet), in size, lined on both sides with noncombustible materials and the building is protected throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

7.3.1.1 Ducts.

The use of nonmetallic ducts shall be permitted where installed in accordance with the limitations of this Code.

7.3.1.2 Piping.

The use of combustible piping materials shall be permitted where installed in accordance with the limitations of this Code.

7.3.1.3 Electrical.

The use of electrical wiring methods with combustible insulation, tubing, raceways and related components shall be permitted where installed in accordance with the limitations of this Code.
PART 8: FIRE AND SMOKE PROTECTION FEATURES

User note:
About this part: Part 8 provides detailed requirements for fire-resistance-rated construction, including structural members, walls, partitions and horizontal assemblies. Other portions of the Code describe where certain fire-resistance-rated elements are required. This Part specifies how these elements are constructed, how openings in walls and partitions are protected and how penetrations of such elements are protected.

8.1 GENERAL

8.1.1 Scope.
The provisions of this part shall govern the materials, systems and assemblies used for structural fire resistance and fire-resistance-rated construction separation of adjacent spaces to safeguard against the spread of fire and smoke within a building and the spread of fire to or from buildings.

8.2 MULTIPLE USE FIRE ASSEMBLIES

8.2.1 Multiple use fire assemblies.
Fire assemblies that serve multiple purposes in a building shall comply with all of the requirements that are applicable for each of the individual fire assemblies.

8.3 FIRE-RESISTANCE RATINGS AND FIRE TESTS

8.3.1 Scope.
Materials prescribed herein for fire resistance shall conform to the requirements of this part.

8.3.2 Fire-resistance ratings.
The fire-resistance rating of building elements, components or assemblies shall be determined in accordance with the test procedures set forth in ASTM E119 or in accordance with Clause 8.3.3. The fire-resistance rating of penetrations and fire-resistant joint systems shall be determined in accordance Clauses 8.14 and 8.15, respectively.

8.3.2.1 Nonsymmetrical wall construction.
Interior walls and partitions of nonsymmetrical construction shall be tested with both faces exposed to the furnace, and the assigned fire-resistance rating shall be the shortest duration obtained from the two tests conducted in compliance with ASTM E119. Where evidence is furnished to show that the wall was tested with the least fire-resistant side exposed to the furnace, subject to acceptance of the building official, the wall need not be subjected to tests from the opposite side (see Clause 8.5.5 for exterior walls).

8.3.2.2 Combustible components.
Combustible aggregates are permitted in gypsum and Portland cement concrete mixtures for fire-resistance-rated construction. Any component material or admixture is permitted in assemblies if the resulting tested assembly meets the fire-resistance test requirements of this Code.

8.3.2.3 Restrained classification.
Fire-resistance-rated assemblies tested under ASTM E119 shall not be considered to be restrained unless evidence satisfactory to the building official is furnished by the registered design professional showing that the construction qualifies for a restrained classification in accordance with ASTM E119. Restrained construction shall be identified on the construction documents.

8.3.2.4 Supplemental features.
Where materials, systems or devices that have not been tested as part of a fire-resistance-rated assembly are incorporated into the building element, component or assembly, sufficient data shall be made available to the building official to show that the required fire-resistance rating is not reduced.

8.3.2.5 Exterior bearing walls.
In determining the fire-resistance rating of exterior bearing walls, compliance with the ASTM E119 criteria for unexposed surface temperature rise and ignition of cotton waste due to passage of flame or gases is required.
only for a period of time corresponding to the required fire-resistance rating of an exterior nonbearing wall with the same fire separation distance, and in a building of the same group. Where the fire-resistance rating determined in accordance with this exception exceeds the fire-resistance rating determined in accordance with ASTM E119, the fire exposure time period, water pressure and application duration criteria for the hose stream test of ASTM E119 shall be based on the fire-resistance rating determined in accordance with this clause.

8.3.3 Methods for determining fire resistance.

The application of any of the methods listed in this clause shall be based on the fire exposure and acceptance criteria specified in ASTM E119. The required fire resistance of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

1. Fire-resistance designs documented in approved sources.

2. Prescriptive designs of fire-resistance-rated building elements, components or assemblies as prescribed in Clause 8.21.

3. Calculations in accordance with Clause 8.22.

4. Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E119.

5. Alternative protection methods as allowed by Clause 1.4.11.

6. Fire-resistance designs certified by an approved agency.

8.3.4 Automatic sprinklers.

Under the prescriptive fire-resistance requirements of this Code, the fire-resistance rating of a building element, component or assembly shall be established without the use of automatic sprinklers or any other fire suppression system being incorporated as part of the assembly tested in accordance with the fire exposure, procedures and acceptance criteria specified in ASTM E119. However, this clause shall not prohibit or limit the duties and powers of the building official allowed by Clauses 1.4.10 and 1.4.11.

8.3.5 Noncombustibility tests.

The tests indicated in Clauses 8.3.5.1 and 8.3.5.2 shall serve as criteria for acceptance of building materials as set forth in clause 7.2.2, 7.2.3 and 7.2.4 in Types I and II construction. The term “non-combustible” does not apply to the flame spread characteristics of interior finish or trim materials. A material shall not be classified as a noncombustible building construction material if it is subject to an increase in combustibility or flame spread beyond the limitations herein established through the effects of age, moisture or other atmospheric conditions.

8.3.6 Fire-resistance-rated glazing.

Fire-resistance-rated glazing, when tested in accordance with ASTM E119 and complying with the requirements of Clause 9.7, shall be permitted. Fire-resistance-rated glazing shall bear a label marked in accordance with Table 8.16.1(1) issued by an agency and shall be permanently identified on the glazing.

8.3.7 Marking and identification.

Where there is an accessible concealed floor, floor-ceiling or attic space, fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings or penetrations shall be effectively and permanently identified with signs or stenciling in the concealed space. Such identification shall:

1. Be located within 4572 mm (15 feet) of the end of each wall and at intervals not exceeding 9144 mm (30 feet) measured horizontally along the wall or partition.

2. Include lettering not less than 76 mm (3 inches) in height with a minimum 9.5 mm (3/8-inch) stroke in a contrasting colour incorporating the suggested wording, “FIRE AND/OR SMOKE BARRIER—PROTECT ALL OPENINGS,” or other wording.
8.4 FIRE-RESISTANCE RATING OF STRUCTURAL MEMBERS

8.4.1 Requirements.

The fire-resistance ratings of structural members and assemblies shall comply with this clause and the requirements for the type of construction as specified in Table 7.1. The fire-resistance ratings shall be not less than the ratings required for the fire-resistance-rated assemblies supported by the structural members.

Exception: Fire barriers, fire partitions, smoke barriers and horizontal assemblies as provided in Clauses 8.7.5, 8.8.4, 8.9.4 and 8.11.2, respectively.

8.4.2 Column protection.

Where columns are required to have protection to achieve a fire-resistance rating, the entire column shall be provided individual encasement protection by protecting it on all sides for the full column height, including connections to other structural members, with materials having the required fire-resistance rating. Where the column extends through a ceiling, the encasement protection shall be continuous from the top of the foundation or floor/ceiling assembly below through the ceiling space to the top of the column.

Exception: Columns that meet the limitations of Clause 8.4.4.1.

8.4.3 Protection of the primary structural frame other than columns.

Members of the primary structural frame other than columns that are required to have protection to achieve a fire-resistance rating and support more than two floors or one floor and roof, or support a load-bearing wall or a nonload-bearing wall more than two stories high, shall be provided individual encasement protection by protecting them on all sides for the full length, including connections to other structural members, with materials having the required fire-resistance rating.

Exception: Individual encasement protection on all sides shall be permitted on all exposed sides provided that the extent of protection is in accordance with the required fire-resistance rating, as determined in Clause 8.3.

8.4.4 Protection of secondary members.

Secondary members that are required to have protection to achieve a fire-resistance rating shall be protected by individual encasement protection.

8.4.4.1 Light-frame construction.

Studs, columns and boundary elements that are integral elements in walls of light-frame construction and are located entirely between the top and bottom plates or tracks shall be permitted to have required fire-resistance ratings provided by the membrane protection provided for the wall.

8.4.4.2 Horizontal assemblies.

Horizontal assemblies are permitted to be protected with a membrane or ceiling where the membrane or ceiling provides the required fire-resistance rating and is installed in accordance with Clause 8.11.

8.4.5 Truss protection.

The required thickness and construction of fire-resistance-rated assemblies enclosing trusses shall be based on the results of full-scale tests or combinations of tests on truss components or on approved calculations based on such tests that satisfactorily demonstrate that the assembly has the required fire resistance.

8.4.6 Attachments to structural members.

The edges of lugs, brackets, rivets and bolt heads attached to structural members shall be permitted to extend to within 25 mm (1 inch) of the surface of the fire protection.

8.4.7 Reinforcing.

Thickness of protection for concrete or masonry reinforcement shall be measured to the outside of the reinforcement except that stirrups and spiral reinforcement ties are permitted to project not more than 12.7 mm (0.5-inch) into the protection.
8.4.8 Embedments and enclosures.

Pipes, wires, conduits, ducts or other service facilities shall not be embedded in the required fire protective covering of a structural member that is required to be individually encased.

8.4.9 Impact protection.

Where the fire protective covering of a structural member is subject to impact damage from moving vehicles, the handling of merchandise or other activity, the fire protective covering shall be protected by corner guards or by a substantial jacket of metal or other noncombustible material to a height adequate to provide full protection, but not less than 1524 mm (5 feet) from the finished floor.

Exception: Corner protection is not required on concrete columns in parking garages.

8.4.10 Exterior structural members.

Load-bearing structural members located within the exterior walls or on the outside of a building or structure shall be provided with the highest fire-resistance rating as determined in accordance with the following:

1. As required by Table 7.1 for the type of building element based on the type of construction of the building.
2. As required by Table 7.1 for exterior bearing walls based on the type of construction.
3. As required by Table 7.2 for exterior walls based on the fire separation distance.

8.4.11 Bottom flange protection.

Fire protection is not required at the bottom flange of lintels, shelf angles and plates, spanning not more than 1931 mm (6 feet 4 inches) whether part of the primary structural frame or not, and from the bottom flange of lintels, shelf angles and plates not part of the structural frame, regardless of span.

8.4.12 Seismic isolation systems.

Fire-resistance ratings for the isolation system shall meet the fire-resistance rating required for the columns, walls or other structural elements in which the isolation system is installed in accordance with Table 7.1. Isolation systems required to have a fire-resistance rating shall be protected with approved materials or construction assemblies designed to provide the same degree of fire resistance as the structural element in which the system is installed when tested in accordance with ASTM E119 (see Clause 8.3.2).

Such isolation system protection applied to isolator units shall be capable of retarding the transfer of heat to the isolator unit in such a manner that the required gravity load-carrying capacity of the isolator unit will not be impaired after exposure to the standard time-temperature curve fire test prescribed in ASTM E119 for a duration not less than that required for the fire-resistance rating of the structure element in which the system is installed.

Such isolation system protection applied to isolator units shall be suitably designed and securely installed so as not to dislodge, loosen, sustain damage or otherwise impair its ability to accommodate the seismic movements for which the isolator unit is designed and to maintain its integrity for the purpose of providing the required fire-resistance protection.

8.4.13 Sprayed fire-resistant materials (SFRM).

Sprayed fire-resistant materials (SFRM) shall comply with Clauses 8.4.13.1 through 8.4.13.5.

8.4.13.1 Fire-resistance rating.

The application of SFRM shall be consistent with the fire-resistance rating and the listing, including, but not limited to, minimum thickness and dry density of the applied SFRM, method of application, substrate surface conditions and the use of bonding adhesives, sealants, reinforcing or other materials.

8.4.13.2 Manufacturer’s installation instructions.

The application of SFRM shall be in accordance with the manufacturer’s installation instructions. The instructions shall include, but are not limited to, substrate temperatures and surface conditions and SFRM handling, storage, mixing, conveyance, method of application, curing and ventilation.
8.4.13.3 Substrate condition.
The SFRM shall be applied to a substrate in compliance with Clauses 8.4.13.3.1 and 8.4.13.3.2.

8.4.13.3.1 Surface conditions.
Substrates to receive SFRM shall be free of dirt, oil, grease, release agents, loose scale and any other condition that prevents adhesion. The substrates shall be free of primers, paints and encapsulants other than those fire tested and listed by a nationally recognized testing agency. Primed, painted or encapsulated steel shall be allowed, provided that testing has demonstrated that required adhesion is maintained.

8.4.13.3.2 Primers, paints and encapsulants.
Where the SFRM is to be applied over primers, paints or encapsulants other than those specified in the listing, the material shall be field tested in accordance with ASTM E736. Where testing of the SFRM with primers, paints or encapsulants demonstrates that required adhesion is maintained, SFRM shall be permitted to be applied to primed, painted or encapsulated wide flange steel shapes in accordance with the following conditions:

1. The beam flange width does not exceed 305 mm (12 inches); or
2. The column flange width does not exceed 400 mm (16 inches); or
3. The beam or column web depth does not exceed 400 mm (16 inches).
4. The average and minimum bond strength values shall be determined based on not fewer than five bond tests conducted in accordance with ASTM E736. Bond tests conducted in accordance with ASTM E736 shall indicate an average bond strength of not less than 80 percent and an individual bond strength of not less than 50 percent, when compared to the bond strength of the SFRM as applied to clean uncoated 3.2 mm (1/8-inch-thick) steel plate.

8.4.13.4 Temperature.
A minimum ambient and substrate temperature of 40°F (4.44°C) shall be maintained during and for not fewer than 24 hours after the application of the SFRM, unless the manufacturer’s instructions allow otherwise.

8.4.13.5 Finished condition.
The finished condition of SFRM applied to structural members or assemblies shall not, upon complete drying or curing, exhibit cracks, voids, spills, delamination or any exposure of the substrate. Surface irregularities of SFRM shall be deemed acceptable.

8.5 EXTERIOR WALLS

8.5.1 General.
Exterior walls shall comply with this clause.

8.5.2 Projections.
Cornices, eave overhangs, exterior balconies and similar projections extending beyond the exterior wall shall conform to the requirements of this clause and Par 15. Exterior Escape balconies and exterior exit stairways and ramps shall comply with Clauses 11.21 and 11.27, respectively. Projections shall not extend any closer to the line used to determine the fire separation distance than shown in Table 8.5.2.

**Exception:** Buildings on the same plot and considered as portions of one building in accordance with Clause 8.5.3 are not required to comply with this clause for projections between the buildings.

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE-FSD (feet)</th>
<th>MINIMUM DISTANCE FROM LINE USED TO DETERMINE FSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to less than 2</td>
<td>Projections not permitted</td>
</tr>
<tr>
<td>2 to less than 3</td>
<td>24 inches</td>
</tr>
<tr>
<td>3 to less than 5</td>
<td>24 inches plus 8 inches for every foot of FSD beyond 3 feet or fraction thereof</td>
</tr>
<tr>
<td>5 or greater</td>
<td>40 inches</td>
</tr>
</tbody>
</table>

**NOTE:** For SI: 1 foot = 304.8 mm; 1 inch = 25.4 mm.

8.5.2.1 Types I construction.
Projections from walls of Type I construction shall be of noncombustible materials or combustible materials as allowed by Clauses 8.5.2.3.1 and 8.5.2.4.
8.5.2.2 Type II, III or IV construction.

Projections from walls of Type II, III or IV construction shall be of any approved material.

8.5.2.3 Combustible projections.

Combustible projections extending to within 1524 mm (5 feet) of the line used to determine the fire separation distance shall be of not less than 1-hour fire-resistance-rated construction, heavy timber construction, complying with Clause 24.4.11, fire-retardant-treated wood or as permitted by Clause 8.5.2.3.1.

Exception: Type IVB construction shall be allowed for combustible projections in Group R-3 and U occupancies with a fire separation distance greater than or equal to 1524 mm (5 feet).

8.5.2.3.1 Balconies and similar projections.

Balconies and similar projections of combustible construction other than fire-retardant-treated wood shall be fire-resistance rated where required by Table 7.1 for floor construction or shall be of heavy timber construction in accordance with Clause 24.4.11. The aggregate length of the projections shall not exceed 50 percent of the building’s perimeter on each floor.

Exceptions:

1. On buildings of Types I construction, three stories or less above grade plane, fire-retardant-treated wood shall be permitted for balconies, porches, decks and exterior stairways not used as required exits.

2. Untreated wood and plastic composites that comply with ASTM D7032 and Clause 27.12 are permitted for pickets, rails and similar guard components that are limited to 42 inches (1067 mm) in height.

3. Balconies and similar projections on buildings of Types II, III and IV construction shall be permitted to be of Type IV construction and shall not be required to have a fire-resistance rating where sprinkler protection is extended to these areas.

4. Where sprinkler protection is extended to the balcony areas, the aggregate length of the balcony on each floor shall not be limited.

8.5.2.4 Bay and oriel windows.

Bay and oriel windows constructed of combustible materials shall conform to the type of construction required for the building to which they are attached.

Exception: Fire-retardant-treated wood shall be permitted on buildings three stories or less above grade plane of Type I, II, III or IV construction.

8.5.3 Buildings on the same plot.

For the purposes of determining the required wall and opening protection, projections and roof-covering requirements, buildings on the same plot shall be assumed to have an imaginary line between them.

Where a new building is to be erected on the same plot as an existing building, the location of the assumed imaginary line with relation to the existing building shall be such that the exterior wall and opening protection of the existing building meet the criteria as set forth in Clauses 8.5.5 and 8.5.8.

Exceptions:

1. Two or more buildings on the same plot shall be either regulated as separate buildings or shall be considered as portions of one building if the aggregate area of such buildings is within the limits specified in Part 6 for a single building. Where the buildings contain different occupancy groups or are of different types of construction, the area shall be that allowed for the most restrictive occupancy or construction.

2. Where an S-2 parking garage of Construction Type I or IIA is erected on the same plot as a Group R-2 building, and there is no fire separation distance between these buildings, then the adjoining exterior walls between the buildings are permitted to have occupant use openings in accordance with Clause 8.6.8. However, opening protective in such openings shall only be required in the exterior wall of the S-2 parking garage, not in the exterior wall
openings in the R-2 building, and these opening protective in the exterior wall of the S-2 parking garage shall be not less than 11/2-hour fire protection rating.

8.5.4 Materials.

Exterior walls shall be of materials permitted by the building type of construction.

8.5.5 Fire-resistance ratings.

Exterior walls shall be fire-resistance rated in accordance with Tables 7.1 and 7.2 and this clause. The required fire-resistance rating of exterior walls with a fire separation distance of greater than 3048 mm (10 feet) shall be rated for exposure to fire from the inside. The required fire-resistance rating of exterior walls with a fire separation distance of less than or equal to 3048 mm (10 feet) shall be rated for exposure to fire from both sides.

8.5.6 Structural stability.

Exterior walls shall extend to the height required by Clause 8.5.11. Interior structural elements that brace the exterior wall but that are not located within the plane of the exterior wall shall have the minimum fire-resistance rating required in Table 601 for that structural element. Structural elements that brace the exterior wall but are located outside of the exterior wall or within the plane of the exterior wall shall have the minimum fire-resistance rating required in this code for the exterior wall.

8.5.7 Unexposed surface temperature.

Where protected openings are not limited by Clause 8.5.8, the limitation on the rise of temperature on the unexposed surface of exterior walls as required by ASTM E119 shall not apply. Where protected openings are limited by Clause 8.5.8, the limitation on the rise of temperature on the unexposed surface of exterior walls as required by ASTM E119 shall not apply provided that a correction is made for radiation from the unexposed exterior wall surface in accordance with the following formula:

\[ Ae = A + (A_f \times Feo) \]

(Equation 8-1)

Where:

\[ Ae \] = Equivalent area of protected openings.

\[ A \] = Actual area of protected openings

\[ A_f \] = Area of exterior wall surface in the storey under consideration exclusive of openings, on which the temperature limitations of ASTM E119 for walls are exceeded.

\[ Feo \] = An “equivalent opening factor” derived from Figure 8.5.7 based on the average temperature of the unexposed wall surface and the fire-resistance rating of the wall.
FIGURE 8.5.7 EQUIVALENT OPENING FACTOR

8.5.8 Openings.
Openings in exterior walls shall comply with Clauses 8.5.8.1 through 8.5.8.6.

TABLE 8.5.8 MAXIMUM AREA OF EXTERIOR WALL OPENINGS BASED ON FIRE SEPARATION DISTANCE AND DEGREE OF OPENING PROTECTION

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE (feet)</th>
<th>DEGREE OF OPENING PROTECTION</th>
<th>ALLOWABLE AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to less than 3(^{b,c,k})</td>
<td>Unprotected, Nonsprinklered (UP, NS)</td>
<td>Not Permitted</td>
</tr>
<tr>
<td></td>
<td>Unprotected, Sprinklered (UP, S)(^{i})</td>
<td>Not Permitted</td>
</tr>
<tr>
<td></td>
<td>Protected (P)</td>
<td></td>
</tr>
<tr>
<td>3 to less than 5(^{d,e})</td>
<td>Unprotected, Nonsprinklered (UP, NS)</td>
<td>Not Permitted</td>
</tr>
<tr>
<td></td>
<td>Unprotected, Sprinklered (UP, S)(^{i})</td>
<td>15(^{%})</td>
</tr>
<tr>
<td></td>
<td>Protected (P)</td>
<td>15(^{%})</td>
</tr>
<tr>
<td>5 to less than 10(^{e,f,j})</td>
<td>Unprotected, Nonsprinklered (UP, NS)</td>
<td>10(^{%})</td>
</tr>
<tr>
<td></td>
<td>Unprotected, Sprinklered (UP, S)(^{i})</td>
<td>25(^{%})</td>
</tr>
<tr>
<td></td>
<td>Protected (P)</td>
<td>25(^{%})</td>
</tr>
<tr>
<td>10 to less than 15(^{e,f,g,j})</td>
<td>Unprotected, Nonsprinklered (UP, NS)</td>
<td>15(^{%})</td>
</tr>
<tr>
<td></td>
<td>Unprotected, Sprinklered (UP, S)(^{i})</td>
<td>45(^{%})</td>
</tr>
<tr>
<td></td>
<td>Protected (P)</td>
<td>45(^{%})</td>
</tr>
<tr>
<td>15 to less than 20(^{f,g,j})</td>
<td>Unprotected, Nonsprinklered (UP, NS)</td>
<td>25(^{%})</td>
</tr>
</tbody>
</table>

Note: For SI: °C = [(°F) - 32] / 1.8.
### 8.5.8.1 Allowable area of openings.

The maximum area of unprotected and protected openings permitted in an exterior wall in any storey of a building shall not exceed the percentages specified in Table 8.5.8 based on the fire separation distance of each individual storey.

#### Exceptions:

1. In other than Group H occupancies, unlimited unprotected openings are permitted in the first storey above grade plane where the wall faces one of the following:
   
   1.1. A street and has a fire separation distance of more than 4572 mm (15 feet).
   
   1.2. An unoccupied space. The unoccupied space shall be on the same plot or dedicated for public use, shall be not less than 30 feet (9144 mm) in width and shall have access from a street by a posted fire lane in accordance with the Ghana Fire Code.

### 8.5.8.2 Protected openings.

Where openings are required to be protected, opening protective shall comply with Clause 8.16.

**Exception:** Opening protective are not required where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 and the exterior openings are protected by a water curtain using automatic sprinklers approved for that use.

### 8.5.8.3 Unprotected openings.

Where unprotected openings are permitted, windows and doors shall be constructed of any approved materials. Glazing shall conform to the requirements of Parts 25 and 27.
8.5.8.4 Mixed openings.

Where both unprotected and protected openings are located in the exterior wall in any storey of a building, the total area of openings shall be determined in accordance with the following:

\[(A_p/a_p) + (A_u/a_u) \leq 1\]

Where:
- \(A_p\) = Actual area of protected openings, or the equipment area of protected openings, \(A_e\) (see Clause 8.5.7).
- \(a_p\) = Allowable area of protected openings.
- \(A_u\) = Actual area of unprotected openings.
- \(a_u\) = Allowable area of unprotected openings.

8.5.8.5 Vertical separation of openings.

Openings in exterior walls in adjacent stories shall be separated vertically to protect against fire spread on the exterior of the buildings where the openings are within 1524 mm (5 feet) of each other horizontally and the opening in the lower storey is not a protected opening with a fire protection rating of not less than 3/4 hour. Such openings shall be separated vertically not less than 914 mm (3 feet) by spandrel girders, exterior walls or other similar assemblies that have a fire-resistance rating of not less than 1 hour, rated for exposure to fire from both sides, or by flame barriers that extend horizontally not less than 762 mm (30 inches) beyond the exterior wall. Flame barriers shall have a fire-resistance rating of not less than 1 hour. The unexposed surface temperature limitations specified in ASTM E119 shall not apply to the flame barriers unless otherwise required by the provisions of this Code.

Exceptions:

1. Opening protectives are not required where the roof assembly of the adjacent building or structure has a fire-resistance rating of not less than 1 hour for a minimum distance of 3048 mm (10 feet) from the exterior wall facing the imaginary line and the entire length and span of the supporting elements for the fire-resistance-rated roof assembly has a fire-resistance rating of not less than 1 hour.

2. Buildings on the same plot and considered as portions of one building in accordance with Clause 8.5.3 are not required to comply with Clause 8.5.6.

8.5.8.6 Vertical exposure.

For buildings on the same plot, opening protectives having a fire protection rating of not less than 3/4 hour shall be provided in every opening that is less than 4572 mm (15 feet) vertically above the roof of an adjacent building or structure based on assuming an imaginary line between them. The opening protectives are required where the fire separation distances from the imaginary line to each building or structure are less than 4572 mm (15 feet).

Exceptions:

1. Opening protectives are not required where the roof assembly of the adjacent building or structure has a fire-resistance rating of not less than 1 hour for a minimum distance of 3048 mm (10 feet) from the exterior wall facing the imaginary line and the entire length and span of the supporting elements for the fire-resistance-rated roof assembly has a fire-resistance rating of not less than 1 hour.

2. Buildings on the same plot and considered as portions of one building in accordance with Clause 8.5.3 are not required to comply with Clause 8.5.6.

8.5.9 Joints.

Joints made in or between exterior walls required by this clause to have a fire-resistance rating shall comply with Clause 8.15.

Exception: Joints in exterior walls that are permitted to have unprotected openings.

8.5.9.1 Voids.

The void created at the interclause of a floor/ceiling assembly and an exterior curtain wall assembly shall be protected in accordance with Clause 8.15.4.

8.5.10 Ducts and air transfer openings.

Penetrations by air ducts and air transfer openings in fire-resistance-rated exterior walls required to have protected openings shall comply with Clause 8.17.
**Exception:** Foundation vents installed in accordance with this Code are permitted.

### 8.5.11 Parapets.

Parapets shall be provided on exterior walls of buildings.

**Exceptions:** A parapet need not be provided on an exterior wall where any of the following conditions exist:

1. The wall is not required to be fire-resistance rated in accordance with this code because of fire separation distance.

2. The building has an area of not more than 1,000 square feet (93 m²) on any floor.

3. Walls that terminate at roofs of not less than 2-hour fire-resistance-rated construction or where the roof, including the deck or slab and supporting construction, is constructed entirely of noncombustible materials.

4. One-hour fire-resistance-rated exterior walls that terminate at the underside of the roof sheathing, deck or slab, provided that:

   4.1. Where the roof/ceiling framing elements are parallel to the walls, such framing and elements supporting such framing shall not be of less than 1-hour fire-resistance-rated construction for a width of 1220 mm (4 feet) for Groups R and U and 3048 mm (10 feet) for other occupancies, measured from the interior side of the wall.

   4.2. Where roof/ceiling framing elements are not parallel to the wall, the entire span of such framing and elements supporting such framing shall not be of less than 1-hour fire-resistance-rated construction.

   4.3. Openings in the roof shall not be located within 5 feet (1524 mm) of the 1-hour fire-resistance-rated exterior wall for Groups R and U and 3048 mm (10 feet) for other occupancies, measured from the interior side of the wall.

4.4. The entire building shall be provided with not less than a Class B roof covering.

5. In Groups R-2 and R-3 where the entire wall is provided with a Class C roof covering, the exterior wall shall be permitted to terminate at the underside of the roof sheathing or deck in Types II, III and IV construction, provided that one or both of the following criteria is met:

   5.1. The roof sheathing or deck is constructed of approved noncombustible materials or of fire-retardant-treated wood for a distance of 1220 mm (4 feet).

   5.2. The roof is protected with 16 mm (0.625-inch) Type X gypsum board directly beneath the underside of the roof sheathing or deck, supported by not less than nominal 2-inch (51 mm) ledgers attached to the sides of the roof framing members for a minimum distance of 1220 mm (4 feet).

6. Where the wall is permitted to have not less than 25 percent of the exterior wall areas containing unprotected openings based on fire separation distance as determined in accordance with Clause 8.5.8.

#### 8.5.11.1 Parapet construction.

Parapets shall have the same fire-resistance rating as that required for the supporting wall, and on any side adjacent to a roof surface, shall have noncombustible faces for the uppermost 457 mm (18 inches), including counterflashing and coping materials. The height of the parapet shall be not less than 762 mm (30 inches) above the point where the roof surface and the wall intersect. Where the roof slopes toward a parapet at a slope greater than two units vertical in 12 units horizontal (16.7-percent slope), the parapet shall extend to the same height as any portion of the roof within a fire separation distance where protection of wall openings is required, but the height shall be not less than 762 mm (30 inches).

### 8.6 FIRE WALLS

#### 8.6.1 General.

Fire walls shall be constructed in accordance with Clauses 8.6.2 through 8.6.11. The extent and location of such fire walls shall provide a complete separation. Where a fire wall separates occupancies that are required to be separated by a fire barrier wall, the most restrictive requirements of each separation shall apply.
8.6.1.1 Party walls.

Any wall located on a plot line between adjacent buildings, which is used or adapted for joint service between the two buildings, shall be constructed as a fire wall in accordance with Clause 8.6. Party walls shall be constructed without openings and shall create separate buildings.

Exceptions:
1. Openings in a party wall separating an anchor building and a mall shall be in accordance with Clause 4.2.4.2.2.1.
2. Fire walls are not required on plot lines dividing a building for ownership purposes where the aggregate height and area of the portions of the building located on both sides of the plot line do not exceed the maximum height and area requirements of this Code. For the Code official's review and approval, he or she shall be provided with copies of dedicated access easements and contractual agreements that permit the owners of portions of the building located on either side of the plot line access to the other side for purposes of maintaining fire and life safety systems necessary for the operation of the building.

8.6.2 Structural stability.

Fire walls shall be designed and constructed to allow collapse of the structure on either side without collapse of the wall under fire conditions. Fire walls designed and constructed in accordance with the Ghana Fire Code shall be deemed to comply with this clause.

Exception: In Seismic Design Categories D through F, where double fire walls are used in accordance with the Ghana Fire Code, floor and roof sheathing not exceeding 3/4 inch (19.05 mm) thickness shall be permitted to be continuous through the wall assemblies of light frame construction.

8.6.3 Materials.

Fire walls shall be of any approved noncombustible materials.

8.6.4 Fire-resistance rating.

Fire walls shall have a fire-resistance rating of not less than that required by Table 8.6.4.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, E, H-4, I, R-1, R-2, U</td>
<td>3 a</td>
</tr>
<tr>
<td>F-1, H-3, H-5, M, S-1</td>
<td>3</td>
</tr>
<tr>
<td>H-1, H-2</td>
<td>4 b</td>
</tr>
<tr>
<td>F-2, S-2, R-3, R-4</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.

b. For Group H-1, H-2 or H-3 buildings, also see Clauses 4.15.7 and 4.15.8.

8.6.5 Horizontal continuity.

Fire walls shall be continuous from exterior wall to exterior wall and shall extend not less than 457 mm (18 inches) beyond the exterior surface of exterior walls.

Exceptions:
1. Fire walls shall be permitted to terminate at the interior surface of combustible exterior sheathing or siding provided that the exterior wall has a fire-resistance rating of not less than 1 hour for a horizontal distance of not less than 1220 mm (4 feet) on both sides of the fire wall. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour.
2. Fire walls shall be permitted to terminate at the interior surface of noncombustible exterior sheathing, exterior siding or other noncombustible exterior finishes provided that the sheathing, siding or other exterior noncombustible finish extends a horizontal distance of not less than 1220 mm (4 feet) on both sides of the fire wall.
3. Fire walls shall be permitted to terminate at the interior surface of noncombustible exterior sheathing where the building on each side of the fire wall is protected by an automatic sprinkler system installed in
accordance with Clause 10.3.3.1.1 and 10.3.3.1.2.

8.6.5.1 Exterior walls.
Where the fire wall intersects exterior walls, the fire-resistance rating and opening protection of the exterior walls shall comply with one of the following:

1. The exterior walls on both sides of the fire wall shall have a 1-hour fire-resistance rating with 3/4-hour protection where opening protection is required by Clause 8.5.8. The fire-resistance rating of the exterior wall shall extend not less than 1220 mm (4 feet) on each side of the interclause of the fire wall to exterior wall. Exterior wall interclauses at fire walls that form an angle equal to or greater than 180 degrees (3.14 rad) do not need exterior wall protection.

2. Buildings or spaces on both sides of the intersecting fire wall shall assume to have an imaginary plot line at the fire wall and extending beyond the exterior of the fire wall. The location of the assumed line in relation to the exterior walls and the fire wall shall be such that the exterior wall and opening protection meet the requirements set forth in Clauses 8.5.5 and 8.5.8. Such protection is not required for exterior walls terminating at fire walls that form an angle equal to or greater than 180 degrees (3.14 rad).

8.6.5.2 Horizontal projecting elements.
Fire walls shall extend to the outer edge of horizontal projecting elements such as balconies, roof overhangs, canopies, marquees and similar projections that are within 1220 mm (4 feet) of the fire wall.

Exceptions:
1. Horizontal projecting elements without concealed spaces, provided that the exterior wall behind and below the projecting element has not less than 1-hour fire-resistance-rated construction for a distance not less than the depth of the projecting element on both sides of the fire wall. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour.

2. Noncombustible horizontal projecting elements with concealed spaces, provided that a minimum 1-hour fire-resistance-rated wall extends through the concealed space. The projecting element shall be separated from the building by not less than 1-hour fire-resistance-rated construction for a distance on each side of the fire wall equal to the depth of the projecting element. The wall is not required to extend under the projecting element where the building exterior wall is not less than 1-hour fire-resistance rated for a distance on each side of the fire wall equal to the depth of the projecting element. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour.

3. For combustible horizontal projecting elements with concealed spaces, the fire wall need only extend through the concealed space to the outer edges of the projecting elements. The exterior wall behind and below the projecting element shall be of not less than 1-hour fire-resistance-rated construction for a distance not less than the depth of the projecting elements on both sides of the fire wall. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour.

8.6.6 Vertical continuity.
Fire walls shall extend from the foundation to a termination point not less than 30 inches (762 mm) above both adjacent roofs.

Exceptions:
1. Stepped buildings in accordance with Clause 8.6.6.1.

2. Two-hour fire-resistance-rated walls shall be permitted to terminate at the underside of the roof sheathing, deck or slab, provided that:
   2.1. The lower roof assembly within 1220 mm (4 feet) of the wall has not less than a 1-hour fire-resistance rating and the entire length and span of supporting elements for the rated roof...
assembly has a fire-resistance rating of not less than 1 hour.

2.2. Openings in the roof shall not be located within 1220 mm (4 feet) of the fire wall.

2.3. Each building shall be provided with not less than a Class B roof covering.

3. Walls shall be permitted to terminate at the underside of noncombustible roof sheathing, deck or slabs where both buildings are provided with not less than a Class B roof covering. Openings in the roof shall not be located within 1220 mm (4 feet) of the fire wall.

4. In buildings of Types II, III and IV construction, walls shall be permitted to terminate at the underside of combustible roof sheathing or decks, provided that all of the following requirements are met:

4.1. Roof openings are not less than 1220 mm (4 feet) from the fire wall.

4.2. The roof is covered with a minimum Class B roof covering.

4.3. The roof sheathing or deck is constructed of fire-retardant-treated wood for a distance of 1220 mm (4 feet) on both sides of the wall or the roof is protected with 15.9 mm (5/8-inch) Type X gypsum board directly beneath the underside of the roof sheathing or deck, supported by not less than 51 mm (2-inch) nominal ledgers attached to the sides of the roof framing members for a distance of not less than 1220 mm (4 feet) on both sides of the fire wall.

5. In buildings designed in accordance with Clause 6.13.2, fire walls located above the 3-hour horizontal assembly required by Clause 6.13.2, Item 1 shall be permitted to extend from the top of this horizontal assembly.

6. Buildings with sloped roofs in accordance with Clause 8.6.6.2.

8.6.6.2 Buildings with sloped roofs.

Where a fire wall serves as an interior wall for a building, and the roof on one side or both sides of the fire wall slopes toward the fire wall at a slope greater than two units vertical in 12 units horizontal (2:12), the fire wall shall extend to a height equal to the height of the roof located 1219 mm (4 feet) from the fire wall plus 762 mm (30 inches). The extension of the fire wall shall be not less than 762 mm (30 inches).

8.6.7 Combustible framing in fire walls.

Adjacent combustible members entering into a concrete or masonry fire wall from opposite sides shall not have less than a 102 mm (4-inch) distance between embedded ends. Where combustible members frame into hollow walls or walls of hollow units, hollow spaces shall be solidly filled for the full thickness of the wall and for a distance not less than 102 mm (4 inches) above, below and between the structural members, with noncombustible materials approved for fireblocking.

8.6.8 Openings.

Each opening through a fire wall shall be protected in accordance with Clause 8.16 and shall not exceed 15 m² (156 square feet). The aggregate width of openings at any floor level shall not exceed 25 percent of the length of the wall.

Exceptions:

1. Openings are not permitted in party walls constructed in accordance with this Code.

2. Openings shall not be limited to 15 m² (156 square feet) where both buildings are equipped having a fire protection rating of not less than 3/4 hour.

Exception: Where the fire wall terminates at the underside of the roof sheathing, deck or slab of the lower roof, provided that:

1. The lower roof assembly within 3048 mm (10 feet) of the wall has not less than a 1-hour fire-resistance rating and the entire length and span of supporting elements for the rated roof assembly has a fire-resistance rating of not less than 1 hour.

2. Openings in the lower roof shall not be located within 10 feet (3048 mm) of the fire wall.
throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.

8.6.9 Penetrations.
Penetrations of fire walls shall comply with Clause 8.14.

8.6.10 Joints.
Joints made in or between fire walls shall comply with Clause 8.15.

8.6.11 Ducts and air transfer openings.
Ducts and air transfer openings shall not penetrate fire walls.

Exception: Penetrations by ducts and air transfer openings of fire walls that are not on a plot line shall be allowed provided that the penetrations comply with Clause 8.17. The size and aggregate width of all openings shall not exceed the limitations of Clause 8.6.8.

8.7 FIRE BARRIERS

8.7.1 General.
Fire barriers installed as required elsewhere in this Code or the Ghana Fire Code shall comply with this clause.

8.7.2 Materials.
Fire barriers shall be of materials permitted by the building type of construction.

8.7.3 Fire-resistance rating.
The fire-resistance rating of fire barriers shall comply with this clause.

8.7.3.1 Shaft enclosures.
The fire-resistance rating of the fire barrier separating building areas from a shaft shall comply with Clause 8.13.4.

8.7.3.2 Interior exit stairway and ramp construction.
The fire-resistance rating of the fire barrier separating building areas from an interior exit stairway or ramp shall comply with Clause 11.23.1.

8.7.3.3 Enclosures for exit access stairways.
The fire-resistance rating of the fire barrier separating building areas from an exit access stairway or ramp shall comply with Clause 8.13.4.

8.7.3.4 Exit passageway.
The fire-resistance rating of the fire barrier separating building areas from an exit passageway shall comply with Clause 11.24.3.

8.7.3.5 Horizontal exit.
The fire-resistance rating of the separation between building areas connected by a horizontal exit shall comply with Clause 11.26.1.

8.7.3.6 Atriums.
The fire barrier separating atriums shall comply with Clause 404.6.

8.7.3.7 Incidental uses.
The fire barrier separating incidental uses from other spaces in the building shall have a fire-resistance rating of not less than that indicated in Table 6.12.

8.7.3.8 Control areas.
Fire barriers separating control areas shall have a fire-resistance rating of not less than that required in Clause 4.14.2.4.

8.7.3.9 Separated occupancies.
Where the provisions of Clause 6.11.4 are applicable, the fire barrier separating mixed occupancies shall have a fire-resistance rating of not less than that indicated in Table 508.4 based on the occupancies being separated.
8.7.3.10 Fire areas.

The fire barriers, fire walls or horizontal assemblies, or combination thereof, separating a single occupancy into different fire areas shall have a fire-resistance rating of not less than that indicated in Table 8.7.3.10. The fire barriers, fire walls or horizontal assemblies, or combination thereof, separating fire areas of mixed occupancies shall have a fire-resistance rating of not less than the highest value indicated in Table 8.7.3.10 for the occupancies under consideration.

TABLE 8.7.3.10 FIRE-RESISTANCE RATING REQUIREMENTS FOR FIRE BARRIERS, FIRE WALLS OR HORIZONTAL ASSEMBLIES BETWEEN FIRE AREAS

<table>
<thead>
<tr>
<th>OCCUPANCY GROUP</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-1, H-2</td>
<td>4</td>
</tr>
<tr>
<td>F-1, H-3, S-1</td>
<td>3</td>
</tr>
<tr>
<td>A, B, E, F-2, H-4, H-5, I, M, R, S-2</td>
<td>2</td>
</tr>
<tr>
<td>U</td>
<td>1</td>
</tr>
</tbody>
</table>

8.7.4 Exterior walls.

Where exterior walls serve as a part of a required fire-resistance-rated shaft or stairway or ramp enclosure, or separation, such walls shall comply with the requirements of Clause 8.5 for exterior walls and the fire-resistance-rated enclosure or separation requirements shall not apply.

Exception: Exterior walls required to be fire-resistance rated in accordance with Clause 11.21 for exterior Escape balconies, Clause 11.23.7 for interior exit stairways and ramps and Clause 11.27.6 for exterior exit stairways and ramp.

8.7.5 Continuity.

Fire barriers shall extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto. Such fire barriers shall be continuous through concealed space, such as the space above a suspended ceiling. Joints and voids at interclauses shall comply with Clauses 8.7.8 and 8.7.9.

Exceptions:
Shaft enclosures shall be permitted to terminate at a top enclosure complying with Clause 8.13.12.

1. Interior exit stairway and ramp enclosures required by Clause 11.23 and exit access stairway and ramp enclosures required by Clause 11.19 shall be permitted to terminate at a top enclosure complying with Clause 8.13.12.

8.7.5.1 Supporting construction.

The supporting construction for a fire barrier shall be protected to afford the required fire-resistance rating of the fire barrier supported. Hollow vertical spaces within a fire barrier shall be fireblocked in accordance with Clause 8.18.2 at every floor level.

Exceptions:

1. The maximum required fire-resistance rating for assemblies supporting fire barriers separating tank storage as provided for in Clause 4.15.9.1.2 shall be 2 hours, but not less than required by Table 7.1 for the building construction type.

2. Supporting construction for 1-hour fire barriers required by Table 509 in buildings of Types IIB, IIIB and VB construction is not required to be fire-resistance rated unless required by other clauses of this Code.

8.7.6 Openings.

Openings in a fire barrier shall be protected in accordance with Clause 8.16. Openings shall be limited to a maximum aggregate width of 25 percent of the length of the wall, and the maximum area of any single opening shall not exceed 15 m² (156 square feet). Openings in enclosures for exit access stairways and ramps, interior exit stairways and ramps and exit passageways shall also comply with Clauses 11.19, 11.23.4 and 11.24.5, respectively.

Exceptions:
1. Openings shall not be limited to 15 m² (156 square feet) where adjoining floor areas are equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

2. Openings shall not be limited to 15 m² (156 square feet) or an aggregate width of 25 percent of the length of the wall where the opening protective is a fire door serving enclosures for exit access stairways and ramps, and interior exit stairways and ramps.

3. Openings shall not be limited to 15 m² (156 square feet) or an aggregate width of 25 percent of the length of the wall where the opening protective has been tested in accordance with ASTM E119 and has a minimum fire-resistance rating not less than the fire-resistance rating of the wall.

4. Fire window assemblies permitted in atrium separation walls shall not be limited to a maximum aggregate width of 25 percent of the length of the wall.

5. Openings shall not be limited to 15 m² (156 square feet) or an aggregate width of 25 percent of the length of the wall where the opening protective is a fire door assembly in a fire barrier separating an enclosure for exit access stairways and ramps, and interior exit stairways and ramps from an exit passageway in accordance with Clause 11.23.3.1.

8.7.7 Penetrations.

Penetrations of fire barriers shall comply with Clause 8.14.

8.7.7.1 Prohibited penetrations.

Penetrations into enclosures for exit access stairways and ramps, interior exit stairways and ramps, and exit passageways shall be allowed only where permitted by Clauses 11.19, 11.23.5 and 11.24.6, respectively.

8.7.8 Joints.

Joints made in or between fire barriers, and joints made at the interclause of fire barriers with underside of a fire-resistance-rated floor or roof sheathing, slab or deck above, and the exterior vertical wall interclause shall comply with Clause 8.15.

8.7.9 Voids at interclauses.

The voids created at the interclause of a fire barrier and a nonfire-resistance-rated roof assembly or a nonfire-resistance-rated exterior wall assembly shall be filled. An approved material or system shall be used to fill the void, and shall be securely installed in or on the interclause for its entire length so as not to dislodge, loosen or otherwise impair its ability to accommodate expected building movements and to retard the passage of fire and hot gases.

8.7.10 Ducts and air transfer openings.

Penetrations in a fire barrier by ducts and air transfer openings shall comply with Clause 8.17.

8.8 FIRE PARTITIONS

8.8.1 General.

The following wall assemblies shall comply with this clause.

1. Separation walls as required by Clause 4.20.2 for Group I-1 and Group R occupancies.

2. Walls separating tenant spaces in covered and open mall buildings as required by Clause 4.2.4.2.1.

3. Corridor walls as required by Clause 11.20.1.

4. Enclosed elevator lobby separation as required by this Code.

5. Escape balconies as required by Clause 11.21.2

8.8.2 Materials.

The walls shall be of materials permitted by the building type of construction.

8.8.3 Fire-resistance rating.

Fire partitions shall have a fire-resistance rating of not less than 1 hour.
Exceptions:

1. Corridor walls permitted to have a 1/2-hour fire-resistance rating by Table 11.20.1.
2. Dwelling unit and sleeping unit separations in buildings of Types IB, IIB and IVB construction shall have fire-resistance ratings of not less than 1/2 hour in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

8.8.4 Continuity.

Fire partitions shall extend from the top of the foundation or floor/ceiling assembly below and be securely attached to one of the following:

1. The underside of the floor or roof sheathing, deck or slab above.
2. The underside of a floor/ceiling or roof/ceiling assembly having a fire-resistance rating that is not less than the fire-resistance rating of the fire partition.

Exceptions:

1. Fire partitions shall not be required to extend into a crawl space below where the floor above the crawl space has a minimum 1-hour fire-resistance rating.
2. Fire partitions serving as a corridor wall shall not be required to extend above the lower membrane of a corridor ceiling provided that the corridor ceiling membrane is equivalent to corridor wall membrane, and either of the following conditions is met:
   1. The room-side membrane of the corridor wall extends to the underside of the floor or roof sheathing, deck or slab above.
   2. The building is equipped with an automatic sprinkler system installed throughout in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, including automatic sprinklers installed in the space between the top of the fire partition and underside of the floor or roof sheathing, deck or slab above.
3. Fire partitions serving as a corridor wall shall be permitted to terminate at the upper membrane of the corridor ceiling assembly where the corridor ceiling is constructed as required for the corridor wall.
4. Fire partitions separating tenant spaces in a covered or open mall building complying with Clause 4.2.4.2.1 shall not be required to extend above the underside of a ceiling. Such ceiling shall not be required to be part of a fire-resistance-rated assembly, and the attic or space above the ceiling at tenant separation walls shall not be required to be subdivided by fire partitions.

8.8.4.1 Supporting construction.

The supporting construction for a fire partition shall have a fire-resistance rating that is equal to or greater than the required fire-resistance rating of the supported fire partition.

Exception: In buildings of Types IB, IIB and IVB construction, the supporting construction requirement shall not apply to fire partitions separating tenant spaces in covered and open mall buildings, fire partitions separating dwelling units, fire partitions separating sleeping units and fire partitions serving as corridor walls.

8.8.4.2 Fireblocks and draftstops in combustible construction.

In combustible construction where fire partitions do not extend to the underside of the floor or roof sheathing, deck or slab above, the space above and along the line of the fire partition shall be provided with one of the following:

1. Fireblocking up to the underside of the floor or roof sheathing, deck or slab above using materials complying with Clause 8.18.2.1.
2. Draftstopping up to the underside of the floor or roof sheathing, deck or slab above using materials complying with Clause 8.18.3.1 for floors or Clause 8.18.4.1 for attics.
Exceptions:

1. Buildings equipped with an automatic sprinkler system installed throughout in accordance with Clause 10.3.3.1.1, or in accordance with Clause 10.3.3.1.2 provided that protection is provided in the space between the top of the fire partition and underside of the floor or roof sheathing, deck or slab above as required for systems complying with Clause 10.3.3.1.1.

2. Where corridor walls provide a sleeping unit or dwelling unit separation, drafstopping shall only be required above one of the corridor walls.

3. In Group R-2 occupancies with fewer than four dwelling units, fireblocking and draftstopping shall not be required.

4. In Group R-2 occupancies up to and including four stories in height in buildings not exceeding 60 feet (18 288 mm) in height above grade plane, the attic space shall be subdivided by draftstops into areas not exceeding 279 m² (3,000 square feet) or above every two dwelling units, whichever is smaller.

5. In Group R-3 occupancies with fewer than three dwelling units, fire-blocking and draftstopping shall not be required in floor assemblies.

8.8.5 Exterior walls.

Where exterior walls serve as a part of a required fire-resistance-rated separation, such walls shall comply with the requirements of Clause 8.5 for exterior walls, and the fire-resistance-rated separation requirements shall not apply.

Exception: Exterior walls required to be fire-resistance rated in accordance with Clause 11.21.2 for exterior Escape balconies, Clause 11.23.7 for interior exit stairways and ramps and Clause 11.27.6 for exterior exit stairways and ramps.

8.8.6 Openings.

Openings in a fire partition shall be protected in accordance with Clause 8.16.

8.8.7 Penetrations.

Penetrations of fire partitions shall comply with Clause 8.14.

8.8.8 Joints.

Joints made in or between fire partitions shall comply with Clause 8.15.

8.8.9 Ducts and air transfer openings.

Penetrations in a fire partition by ducts and air transfer openings shall comply with Clause 8.17.

8.9 SMOKE BARRIERS

8.9.1 General.

Vertical and horizontal smoke barriers shall comply with this clause.

8.9.2 Materials.

Smoke barriers shall be of materials permitted by the building type of construction.

8.9.3 Fire-resistance rating.

A 1-hour fire-resistance rating is required for smoke barriers.

Exception: Smoke barriers constructed of minimum 2.5 mm (0.10-inch-thick) steel in Group I-3 buildings.

8.9.4 Continuity.

Smoke barriers shall form an effective membrane continuous from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, deck or slab above, including continuity through concealed spaces, such as those found above suspended ceilings, and interstitial structural and mechanical spaces. The supporting construction shall be protected to afford the required fire-resistance rating of the wall or floor supported in buildings of other than Type I B, IIB or IVB construction. Smoke barrier walls used to separate smoke compartments shall comply with Clause 8.9.4.1. Smoke-barrier walls used to enclose areas of refuge in accordance with this Code or to enclose
8.9.4.1 Smoke-barrier walls separating smoke compartments.

Smoke-barrier walls used to separate smoke compartments shall form an effective membrane continuous from outside wall to outside wall.

8.9.4.2 Smoke-barrier walls enclosing areas of refuge or elevator lobbies.

Smoke-barrier walls used to enclose areas of refuge in accordance with this Code or to enclose elevator lobbies in accordance with this Code shall form an effective membrane enclosure that terminates at a fire barrier wall having a level of fire protection rating not less than 1 hour, another smoke barrier wall or an outside wall. A smoke and draft control door assembly as specified in Clause 8.16.2.2.1.1 shall not be required at each elevator hoistway door opening or at each exit doorway between an area of refuge and the exit enclosure.

8.9.5 Openings.

Openings in a smoke barrier shall be protected in accordance with Clause 8.16.

Exceptions:

1. In Group I-1, Condition 2, Group I-2 and ambulatory care facilities, where a pair of opposite-swinging doors are installed across a corridor in accordance with Clause 8.9.5.1, the doors shall not be required to be protected in accordance with Clause 8.16. The doors shall be close fitting within operational tolerances, and shall not have a center mullion or undercuts in excess of 19.1 mm (3/4 inch), louvers or grilles. The doors shall have head and jamb stops, and astragals or rabbets at meeting edges. Where permitted by the door manufacturer’s listing, positive-latching devices are not required.

Factory-applied or field-applied protective plates are not required to be labeled.

2. In Group I-1, Condition 2, Group I-2 and ambulatory care facilities, special purpose horizontal sliding, accordion or folding doors installed in accordance with Clause 11.10.1.4.3 and protected in accordance with Clause 8.16.

8.9.5.1 Group I-2 and ambulatory care facilities.

In Group I-2 and ambulatory care facilities, where doors protecting openings in smoke barriers are installed across a corridor and have hold-open devices, the doors shall be automatic-closing in accordance with Clause 8.16.2.6.6. Such doors shall have a vision panel with fire-protection-rated glazing materials in fire-protection-rated frames, the area of which shall not exceed that tested.

8.9.6 Penetrations.

Penetrations of smoke barriers shall comply with Clause 8.14.

8.9.7 Joints.

Joints made in or between smoke barriers shall comply with Clause 8.15.

8.9.8 Ducts and air transfer openings.

Penetrations in a smoke barrier by ducts and air transfer openings shall comply with Clause 8.17.

8.10 SMOKE PARTITIONS

8.10.1 General.

Smoke partitions installed as required elsewhere in the Code shall comply with this clause.

8.10.2 Materials.

The walls shall be of materials permitted by the building type of construction.
8.10.3 Fire-resistance rating.

Unless required elsewhere in the Code, smoke partitions are not required to have a fire-resistance rating.

8.10.4 Continuity.

Smoke partitions shall extend from the top of the foundation or floor below to the underside of the floor or roof sheathing, deck or slab above or to the underside of the ceiling above where the ceiling membrane is constructed to limit the transfer of smoke.

8.10.5 Openings.

Openings in smoke partitions shall comply with Clauses 8.10.5.1 and 8.10.5.2.

8.10.5.1 Windows.

Windows in smoke partitions shall be sealed to resist the free passage of smoke or be automatic-closing upon detection of smoke.

8.10.5.2 Doors.

Doors in smoke partitions shall comply with Clauses 8.10.5.2.1 through 8.10.5.2.3.

8.10.5.2.1 Louvers.

Doors in smoke partitions shall not include louvers.

8.10.5.2.2 Smoke and draft control doors.

Where required elsewhere in the Code, doors in smoke partitions shall meet the requirements for a smoke and draft control door assembly tested in accordance with this Code. The air leakage rate of the door assembly shall not exceed \(0.015424 \, \text{m}^3/(\text{s} \cdot \text{m}^2)\) (3.0 cubic feet per minute per square foot) of door opening at 24.9 Pa (0.10 inch) of water for both the ambient temperature test and the elevated temperature exposure test. Installation of smoke doors shall be in accordance with Ghana Fire Code.

8.10.5.2.2.1 Smoke and draft control door labeling.

Smoke and draft control doors complying with this Code shall be permitted to show the letter “S” on the manufacturer’s labeling.

8.10.5.2.3 Self- or automatic-closing doors.

Where required elsewhere in the Code, doors in smoke partitions shall be self- or automatic-closing by smoke detection in accordance with Code.

8.10.6 Penetrations.

The space around penetrating items shall be filled with an approved material to limit the free passage of smoke.

8.10.7 Joints.

Joints shall be filled with an approved material to limit the free passage of smoke.

8.10.8 Ducts and air transfer openings.

The space around a duct penetrating a smoke partition shall be filled with an approved material to limit the free passage of smoke. Air transfer openings in smoke partitions shall be provided with a smoke damper complying with Clause 8.17.3.2.2.

Exception: Where the installation of a smoke damper will interfere with the operation of a required smoke control system in accordance with Clause 10.9, approved alternative protection shall be utilized.

8.11 FLOOR AND ROOF ASSEMBLIES

8.11.1 General.

Horizontal assemblies shall comply with Clause 8.11.2. Nonfire-resistance-rated floor and roof assemblies shall comply with Clause 8.11.3.

8.11.2 Horizontal assemblies.

Horizontal assemblies shall comply with Clauses 8.11.2.1 through 8.11.2.6.
8.11.2.1 Materials.
Assemblies shall be of materials permitted by the building type of construction.

8.11.2.2 Continuity.
Assemblies shall be continuous without vertical openings, except as permitted by this clause and Clause 8.12.

8.11.2.3 Supporting construction.
The supporting construction shall be protected to afford the required fire-resistance rating of the horizontal assembly supported.

Exception: In buildings of Type IB, IIB or IVB construction, the construction supporting the horizontal assembly is not required to be fire-resistance rated at the following:

1. Horizontal assemblies at the separations of incidental uses as specified by this Code provided that the required fire-resistance rating does not exceed 1 hour.

2. Horizontal assemblies at the separations of dwelling units and sleeping units as required by Clause 4.20.3.

3. Horizontal assemblies at smoke barriers constructed in accordance with Clause 8.9.

8.11.2.4 Fire-resistance rating.
The fire-resistance rating of horizontal assemblies shall comply with Clauses 8.11.2.4.1 through 8.11.2.4.6 but shall be not less than that required by the building type of construction.

8.11.2.4.1 Separating mixed occupancies.
Where the horizontal assembly separates mixed occupancies, the assembly shall have a fire-resistance rating of not less than that required by Clause 6.11.4 based on the occupancies being separated.

8.11.2.4.2 Separating fire areas.
Where the horizontal assembly separates a single occupancy into different fire areas, the assembly shall have a fire-resistance rating of not less than that required by Clause 8.7.3.10.

8.11.2.4.3 Dwelling units and sleeping units.
Horizontal assemblies serving as dwelling or sleeping unit separations in accordance with Clause 4.20.3 shall be not less than 1-hour fire-resistance-rated construction.

Exception: Horizontal assemblies separating dwelling units and sleeping units shall be not less than 1/2-hour fire-resistance-rated construction in a building of Types IB, IIB and IVB construction, where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

8.11.2.4.4 Separating smoke compartments.
Where the horizontal assembly is required to be a smoke barrier, the assembly shall comply with Clause 8.9.

8.11.2.4.5 Separating incidental uses.
Where the horizontal assembly separates incidental uses from the remainder of the building, the assembly shall have a fire-resistance rating of not less than that required by Clause 6.12.

8.11.2.4.6 Other separations.
Where a horizontal assembly is required by other clauses of this Code, the assembly shall have a fire-resistance rating of not less than that required by that clause.

8.11.2.5 Ceiling panels.
Where the weight of lay-in ceiling panels, used as part of fire-resistance-rated floor/ceiling or roof/ceiling assemblies, is not adequate to resist an upward force of 48 Pa (1 pound per square foot), wire or other approved devices shall be installed above the panels to prevent vertical displacement under such upward force.

8.11.2.6 Unusable space.
In 1-hour fire-resistance-rated floor/ceiling assemblies, the ceiling membrane is not required to be installed over unusable crawl
spaces. In 1-hour fire-resistance-rated roof assemblies, the floor membrane is not required to be installed where unusable attic space occurs above.

8.11.3 Nonfire-resistance-rated floor and roof assemblies.

Nonfire-resistance-rated floor, floor/ceiling, roof and roof/ceiling assemblies shall comply with Clauses 8.11.3.1 and 8.11.3.2.

8.11.3.1 Materials.
Assemblies shall be of materials permitted by the building type of construction.

8.11.3.2 Continuity.
Assemblies shall be continuous without vertical openings, except as permitted by Clause 8.12.

8.12 VERTICAL OPENINGS

8.12.1 General.
Each vertical opening shall comply in accordance with one of the protection methods in Clauses 8.12.1.1 through 8.12.1.16.

8.12.1.1 Shaft enclosures.
Vertical openings contained entirely within a shaft enclosure complying with Clause 8.13 shall be permitted.

8.12.1.2 Individual dwelling unit.
Unconcealed vertical openings totally within an individual residential dwelling unit and connecting four stories or less shall be permitted.

8.12.1.3 Escalator openings.
Where a building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, vertical openings for escalators shall be permitted where protected in accordance with Clause 8.12.1.3.1 or 8.12.1.3.2.

8.12.1.3.1 Opening size.
Protection by a draft curtain and closely spaced sprinklers in accordance with the Ghana Fire Code shall be permitted where the area of the vertical opening between stories does not exceed twice the horizontal projected area of the escalator. In other than Groups B and M, this application is limited to openings that do not connect more than four stories.

8.12.1.3.2 Automatic shutters.
Protection of the vertical opening by approved shutters at every penetrated floor shall be permitted in accordance with this clause. The shutters shall be of noncombustible construction and have a fire-resistance rating of not less than 1.5 hours. The shutter shall be so constructed as to close immediately upon the actuation of a smoke detector installed in accordance with Clause 10.7.3.1 and shall completely shut off the well opening. Escalators shall cease operation when the shutter begins to close. The shutter shall operate at a speed of not more than 30 feet per minute (152.4 mm/s) and shall be equipped with a sensitive leading edge to arrest its progress where in contact with any obstacle, and to continue its progress on release therefrom.

8.12.1.4 Penetrations.
Penetrations, concealed and unconcealed, shall be permitted where protected in accordance with Clause 8.14.

8.12.1.5 Joints.
Joints shall be permitted where complying with Clause 8.12.1.5.1 or 8.12.1.5.2, as applicable.

8.12.1.5.1 Joints in or between horizontal assemblies.
Joints made in or between horizontal assemblies shall comply with Clause 8.15. The void created at the interclause of a floor/ceiling assembly and an exterior curtain wall assembly shall be permitted where protected in accordance with Clause 8.15.4.
8.12.1.5.2 Joints in or between nonfire-resistance-rated floor assemblies.

Joints in or between floor assemblies without a required fire-resistance rating shall be permitted where they comply with one of the following:

1. The joint shall be concealed within the cavity of a wall.

2. The joint shall be located above a ceiling.

3. The joint shall be sealed, treated or covered with an approved material or system to resist the free passage of flame and the products of combustion.

Exception: Joints meeting one of the exceptions listed in Clause 8.15.1.

8.12.1.6 Ducts and air transfer openings.

Penetrations by ducts and air transfer openings shall be protected in accordance with Clause 8.17. Grease ducts shall be protected in accordance with this Code.

8.12.1.7 Atriums.

In other than Group H occupancies, atriums complying with Clause 4.4 shall be permitted.

8.12.1.8 Masonry chimney.

Approved vertical openings for masonry chimneys shall be permitted where the annular space is fireblocked at each floor level in accordance with Clause 8.18.2.5.

8.12.1.9 Two-storey openings.

In other than Groups I-2 and I-3, a vertical opening that is not used as one of the applications listed in this clause shall be permitted if the opening complies with all of the following items:

1. Does not connect more than two stories.

2. Does not penetrate a horizontal assembly that separates fire areas or smoke barriers that separate smoke compartments.

3. Is not concealed within the construction of a wall or a floor/ceiling assembly.

4. Is not open to a corridor in Group I and R occupancies.

5. Is not open to a corridor on nonsprinklered floors.

6. Is separated from floor openings and air transfer openings serving other floors by construction conforming to required shaft enclosures.

8.12.1.10 Parking garages.

Vertical openings in parking garages for automobile ramps, elevators and duct systems shall comply with Clause 8.12.1.10.1, 8.12.1.10.2 or 8.12.1.10.3, as applicable.

8.12.1.10.1 Automobile ramps.

Vertical openings for automobile ramps in parking garages shall be permitted where constructed in accordance with Clauses 4.6.5 and 4.6.6.

8.12.1.10.2 Elevators.

Vertical openings for elevator hoistways in parking garages that serve only the parking garage, and complying with Clauses 4.6.5 and 4.6.6, respectively, shall be permitted.

8.12.1.10.3 Duct systems.

Vertical openings for mechanical exhaust or supply duct systems in parking garages complying with Clauses 4.6.5 and 4.6.6, respectively, shall be permitted to be unenclosed where such duct system is contained within and serves only the parking garage.

8.12.1.11 Mezzanine.

Vertical openings between a mezzanine complying with this Code and the floor below shall be permitted.

8.12.1.12 Exit access stairways and ramps.

Vertical openings containing exit access stairways or ramps in accordance with this Code shall be permitted.
8.12.1.13 Openings.
Vertical openings for floor fire doors and access doors shall be permitted where protected by Clause 8.12.1.13.1 or 8.12.1.13.2.

8.12.1.13.1 Horizontal fire door assemblies.
Horizontal fire door assemblies used to protect openings in fire-resistance-rated horizontal assemblies shall be tested in accordance with the Ghana Fire Code, and shall achieve a fire-resistance rating not less than the assembly being penetrated. Horizontal fire door assemblies shall be labeled by an approved agency. The label shall be permanently affixed and shall specify the manufacturer, the test standard and the fire-resistance rating.

8.12.1.13.2 Access doors.
Access doors shall be permitted in ceilings of fire-resistance-rated floor/ceiling and roof/ceiling assemblies, provided that such doors are tested in accordance with ASTM E119 as horizontal assemblies and labeled by an approved agency for such purpose.

In Group I-3 occupancies, vertical openings shall be permitted in accordance with Clause 408.5.

8.12.1.15 Skylights.
Skylights and other penetrations through a fire-resistance-rated roof deck or slab are permitted to be unprotected, provided that the structural integrity of the fire-resistance-rated roof assembly is maintained. Unprotected skylights shall not be permitted in roof assemblies required to be fire-resistance rated in accordance with Clause 8.5.8.6. The supporting construction shall be protected to afford the required fire-resistance rating of the horizontal assembly supported.

8.12.1.16 Openings otherwise permitted.
Vertical openings shall be permitted where allowed by other clauses of this Code.

8.13 SHAFT ENCLOSURES

8.13.1 General.
The provisions of this clause shall apply to shafts required to protect openings and penetrations through floor/ceiling and roof/ceiling assemblies. Interior exit stairways and ramps shall be enclosed in accordance with Clause 11.23.

8.13.2 Construction.
Shaft enclosures shall be constructed as fire barriers in accordance with Clause 8.7 or horizontal assemblies in accordance with Clause 8.11, or both.

8.13.3 Materials.
The shaft enclosure shall be of materials permitted by the building type of construction.

8.13.4 Fire-resistance rating.
Shaft enclosures shall have a fire-resistance rating of not less than 2 hours where connecting four stories or more, and not less than 1 hour where connecting less than four stories. The number of stories connected by the shaft enclosure shall include any basements but not any mezzanines. Shaft enclosures shall have a fire-resistance rating not less than the floor assembly penetrated, but need not exceed 2 hours. Shaft enclosures shall meet the requirements of Clause 8.3.2.1.

8.13.5 Continuity.
Shaft enclosures shall be constructed as fire barriers in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both, and shall have continuity in accordance with Clause 8.7.5 for fire barriers or Clause 8.11.2.2 for horizontal assemblies, as applicable.

8.13.6 Exterior walls.
Where exterior walls serve as a part of a required shaft enclosure, such walls shall comply with the requirements of Clause 8.5 for exterior walls and the fire-resistance-rated enclosure requirements shall not apply.
**Exception:** Exterior walls required to be fire-resistance rated in accordance with Clause 11.21.2 for exterior Escape balconies, Clause 11.23.7 for interior exit stairways and ramps and Clause 11.27.6 for exterior exit stairways and ramps.

**8.13.7 Openings.**

Openings in a shaft enclosure shall be protected in accordance with Clause 8.16 as required for fire barriers. Doors shall be self- or automatic-closing by smoke detection in accordance with Clause 8.16.2.6.6.

**8.13.7.1 Prohibited openings.**

Openings other than those necessary for the purpose of the shaft shall not be permitted in shaft enclosures.

**8.13.8 Penetrations.**

Penetrations in a shaft enclosure shall be protected in accordance with Clause 8.14 as required for fire barriers. Structural elements, such as beams or joists, where protected in accordance with Clause 8.14 shall be permitted to penetrate a shaft enclosure.

**8.13.8.1 Prohibited penetrations.**

Penetrations other than those necessary for the purpose of the shaft shall not be permitted in shaft enclosures.

**Exception:** Membrane penetrations shall be permitted on the outside of shaft enclosures. Such penetrations shall be protected in accordance with Clause 8.14.4.2.

**8.13.9 Joints.**

Joints in a shaft enclosure shall comply with Clause 8.15.

**8.13.10 Duct and air transfer openings.**

Penetrations of a shaft enclosure by ducts and air transfer openings shall comply with Clause 717.

**8.13.11 Enclosure at the bottom.**

Shafts that do not extend to the bottom of the building or structure shall comply with one of the following:

1. They shall be enclosed at the lowest level with construction of the same fire-resistance rating as the lowest floor through which the shaft passes, but not less than the rating required for the shaft enclosure.

2. They shall terminate in a room having a use related to the purpose of the shaft. The room shall be separated from the remainder of the building by fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. The fire-resistance rating and opening protective shall be not less than the protection required for the shaft enclosure.

3. They shall be protected by approved fire dampers installed in accordance with their listing at the lowest floor level within the shaft enclosure.

**Exceptions:**

1. The fire-resistance-rated room separation is not required, provided that the only openings in or penetrations of the shaft enclosure to the interior of the building occur at the bottom. The bottom of the shaft shall be closed off around the penetrating items with materials permitted by Clause 8.18.3.1 for draftstopping, or the room shall be provided with an approved automatic sprinkler system.

2. A shaft enclosure containing a waste or linen chute shall not be used for any other purpose and shall discharge in a room protected in accordance with Clause 8.13.13.4.

3. The fire-resistance-rated room separation and the protection at the bottom of the shaft are not required provided that there are no combustibles in the shaft and there are no openings or other penetrations through the shaft enclosure to the interior of the building.
8.13.12 Enclosure at top.
A shaft enclosure that does not extend to the underside of the roof sheathing, deck or slab of the building shall be enclosed at the top with construction of the same fire-resistance rating as the topmost floor penetrated by the shaft, but not less than the fire-resistance rating required for the shaft enclosure.

8.13.13 Waste and linen chutes and incinerator rooms.

Exception: Chutes serving and contained within a single dwelling unit.

A shaft enclosure containing a recycling, or waste or linen chute shall not be used for any other purpose and shall be enclosed in accordance with Clause 8.13.4. A shaft enclosure shall be permitted to contain recycling and waste chutes. Openings into the shaft, from access rooms and discharge rooms, shall be protected in accordance with this clause and Clause 8.16. Openings into chutes shall not be located in corridors. Doors into chutes shall be self-closing. Discharge doors shall be self- or automatic-closing upon the actuation of a smoke detector in accordance with Clause 8.16.2.6.6, except that heat-activated closing devices shall be permitted between the shaft and the discharge room.

8.13.13.2 Materials.
A shaft enclosure containing a waste, recycling, or linen chute shall be constructed of materials as permitted by the building type of construction.

8.13.13.3 Chute access rooms.
Access openings for waste or linen chutes shall be located in rooms or compartments enclosed by not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. Openings into the access rooms shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour. Doors shall be self- or automatic-closing upon the detection of smoke in accordance with Clause 8.16.2.6.6. The room or compartment shall be configured to allow the access door to the room or compartment to close and latch with the access panel to the refuse or laundry chute in any position.

8.13.13.4 Chute discharge room.
Waste or linen chutes shall discharge into an enclosed room separated by fire barriers with a fire-resistance rating not less than the required fire rating of the shaft enclosure and constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. Openings into the discharge room from the remainder of the building shall be protected by opening protectives having a fire protection rating equal to the protection required for the shaft enclosure. Doors shall be self- or automatic-closing upon the detection of smoke in accordance with Clause 8.16.2.6.6. Waste chutes shall not terminate in an incinerator room. Waste and linen rooms that are not provided with chutes need only comply with Table 509.

8.13.13.5 Incinerator room.
Incinerator rooms shall comply with this Code.

8.13.13.6 Automatic sprinkler system.
An approved automatic sprinkler system shall be installed in accordance with Clause 10.3.2.11.2.

8.13.14 Elevator, dumbwaiter and other hoistways.
Elevator, dumbwaiter and other hoistway enclosures shall be constructed in accordance with Clauses 712 and 713, and Part 30.

8.14 PENETRATIONS

8.14.1 Scope.
The provisions of this clause shall govern the materials and methods of construction used to protect through penetrations and membrane
8.14.1 Ducts and air transfer openings.

Penetrations of fire-resistance-rated walls by ducts that are not protected with dampers shall comply with Clauses 8.14.3 through 8.14.4.3. Penetrations of horizontal assemblies not protected with a shaft as permitted by Clause 8.17.6, and not required to be protected with fire dampers by other clauses of this Code, shall comply with Clauses 8.14.5 through 8.14.6.2. Ducts and air transfer openings that are protected with dampers shall comply with Clause 8.17.

8.14.2 Installation.

A listed penetration firestop system shall be installed in accordance with the manufacturer's installation instructions and the listing criteria.

8.14.3 Installation details.

Where sleeves are used, they shall be securely fastened to the assembly penetrated. The space between the item contained in the sleeve and the sleeve itself and any space between the sleeve and the assembly penetrated shall be protected in accordance with this clause. Insulation and coverings on or in the penetrating item shall not penetrate the assembly unless the specific material used has been tested as part of the assembly in accordance with this clause.


Penetrations into or through fire walls, fire barriers, smoke barrier walls and fire partitions shall comply with Clauses 8.14.4.1 through 8.14.4.3. Penetrations in smoke barrier walls shall also comply with Clause 8.14.5.4.

8.14.4.1 Through penetrations.

Through penetrations of fire-resistance-rated walls shall comply with Clause 8.14.4.1.1 or 8.14.4.1.2.

Exception: Where the penetrating items are steel, ferrous or copper pipes, tubes or conduits, the annular space between the penetrating item and the fire-resistance-rated wall is permitted to be protected by either of the following measures:

1. In concrete or masonry walls where the penetrating item is a maximum 152 mm (6-inch) nominal diameter and the area of the opening through the wall does not exceed 0.0929 m² (144 square inches), concrete, grout or mortar is permitted where installed the full thickness of the wall or the thickness required to maintain the fire-resistance rating.

2. The material used to fill the annular space shall prevent the passage of flame and hot gases sufficient to ignite cotton waste when subjected to ASTM E119 time-temperature fire conditions under a minimum positive pressure differential of 2.49 Pa (0.01 inch) of water at the location of the penetration for the time period equivalent to the fire-resistance rating of the construction penetrated.

8.14.4.1.1 Fire-resistance-rated assemblies.

Through penetrations shall be protected using systems installed as tested in the approved fire-resistance-rated assembly.

8.14.4.1.2 Through-penetration firestop system.

Through penetrations shall be protected by an approved penetration firestop system installed as tested in accordance with ASTM E814, with a minimum positive pressure differential of 2.49 Pa (0.01 inch) of water and shall have an F rating of not less than the required fire-resistance rating of the wall penetrated.

8.14.4.2 Membrane penetrations.

Membrane penetrations shall comply with Clause 8.14.4.1. Where walls or partitions are required to have a fire-resistance rating, recessed fixtures shall be installed such that the required fire resistance will not be reduced.

Exceptions:

1. Membrane penetrations of maximum 2-hour fire-resistance-rated walls and partitions by steel electrical boxes that do not exceed 0.0103 m² (16 square inches) in area, provided that the aggregate area of the openings through the membrane does not exceed 0.0645 m² (100 square inches) in any 9.29 m² (100
such boxes on opposite sides of the wall or partition shall be separated by one of the following:

1.1. By a horizontal distance of not less than 610 mm (24 inches) where the wall or partition is constructed with individual noncommunicating stud cavities.

1.2. By a horizontal distance of not less than the depth of the wall cavity where the wall cavity is filled with cellulose loose-fill, rockwool or slag mineral wool insulation.

1.3. By solid fireblocking in accordance with Clause 8.18.2.1.

1.4. By protecting both outlet boxes with listed putty pads.

1.5. By other listed materials and methods.

2. Membrane penetrations by listed electrical boxes of any material, provided that such boxes have been tested for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the listing. The annular space between the wall membrane and the box shall not exceed 3.2 mm (1/8 inch) unless listed otherwise. Such boxes on opposite sides of the wall or partition shall be separated by one of the following:

2.1. By the horizontal distance specified in the listing of the electrical boxes.

2.2. By solid fireblocking in accordance with Clause 8.18.2.1.

2.3. By protecting both boxes with listed putty pads.

2.4. By other listed materials and methods.

3. Membrane penetrations by electrical boxes of any size or type, that have been listed as part of a wall opening protective material system for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the listing.

4. Membrane penetrations by boxes other than electrical boxes, provided that such penetrating items and the annular space between the wall membrane and the box, are protected by an approved membrane penetration firestop system installed as tested in accordance with ASTM E814, with a minimum positive pressure differential of 2.49 Pa (0.01 inch) of water, and shall have an F and T rating of not less than the required fire-resistance rating of the wall penetrated and be installed in accordance with their listing.

5. The annular space created by the penetration of an automatic sprinkler, provided that it is covered by a metal escutcheon plate.

6. Membrane penetrations of maximum 2-hour fire-resistance-rated walls and partitions by steel electrical boxes that exceed 0.0103 m² (16 square inches) in area, or steel electrical boxes of any size having an aggregate area through the membrane exceeding 0.0645 m² (100 square inches) in any 9.29 m² (100 square feet) of wall area, provided that such penetrating items are protected by listed putty pads or other listed materials and methods, and installed in accordance with the listing.

8.14.4.3 Dissimilar materials.

Noncombustible penetrating items shall not connect to combustible items beyond the point of firestopping unless it can be demonstrated that the fire-resistance integrity of the wall is maintained.

8.14.5 Horizontal assemblies.

Penetrations of a fire-resistance-rated floor, floor/ceiling assembly or the ceiling membrane of a roof/ceiling assembly not required to be enclosed in a shaft by Clause 8.12.1 shall be protected in accordance with Clauses 8.14.5.1 through 8.14.5.4.

8.14.5.1 Through penetrations.

Through penetrations of horizontal assemblies shall comply with this Code.

Exceptions:

1. Penetrations by steel, ferrous or copper conduits, pipes, tubes or vents or concrete or masonry items through a single fire-resistance-rated floor assembly where the annular space is protected with materials that prevent the passage of flame and hot gases sufficient to ignite cotton waste when subjected to ASTM E119 time-temperature fire conditions under a minimum positive pressure differential of 2.49 Pa (0.01 inch) of water at the location of the penetration for the time period equivalent to the
fire-resistance rating of the construction penetrated. Penetrating items with a maximum 152 mm (6-inch) nominal diameter shall not be limited to the penetration of a single fire-resistance-rated floor assembly, provided that the aggregate area of the openings through the assembly does not exceed 92,900 mm² (144 square inches) in any 9.3 m² (100 square feet) of floor area.

2. Penetrations in a single concrete floor by steel, ferrous or copper conduits, pipes, tubes or vents with a maximum 152 mm (6-inch) nominal diameter, provided that the concrete, grout or mortar is installed the full thickness of the floor or the thickness required to maintain the fire-resistance rating. The penetrating items shall not be limited to the penetration of a single concrete floor, provided that the area of the opening through each floor does not exceed 92,900 mm² (144 square inches).

3. Penetrations by listed electrical boxes of any material, provided that such boxes have been tested for use in fire-resistance-rated assemblies and installed in accordance with the instructions included in the listing.

8.14.5.1.1 Fire-resistance-rated assemblies.

Through penetrations shall be protected using systems installed as tested in the approved fire-resistance-rated assembly.

8.14.5.1.2 Through-penetration firestop system.

Through penetrations shall be protected by an approved through-penetration firestop system installed and tested in accordance with ASTM E814, with a minimum positive pressure differential of 0.01 inch of water (2.49 Pa). The system shall have an F rating/T rating of not less than 1 hour but not less than the required rating of the floor penetrated.

Exceptions:

1. Floor penetrations contained and located within the cavity of a wall above the floor or below the floor do not require a T rating.

2. Floor penetrations by floor drains, tub drains or shower drains contained and located within the concealed space of a horizontal assembly do not require a T rating.

3. Floor penetrations of maximum 102 mm (4-inch) nominal diameter metal conduit or tubing penetrating directly into metal-enclosed electrical power switchgear do not require a T rating.

8.14.5.2 Membrane penetrations.

Penetrations of membranes that are part of a horizontal assembly shall comply with Clause 8.14.5.1.1 or 8.14.5.1.2. Where floor/ceiling assemblies are required to have a fire-resistance rating, recessed fixtures shall be installed such that the required fire resistance will not be reduced.

Exceptions:

1. Membrane penetrations by steel, ferrous or copper conduits, pipes, tubes or vents, or concrete or masonry items where the annular space is protected either in accordance with Clause 8.14.5.1 or to prevent the free passage of flame and the products of combustion. The aggregate area of the openings through the membrane shall not exceed 64,500 mm² (100 square inches) in any 9.3 m² (100 square feet) of ceiling area in assemblies tested without penetrations.

2. Ceiling membrane penetrations of maximum 2-hour horizontal assemblies by steel electrical boxes that do not exceed 10,323 mm² (16 square inches) in area, provided that the aggregate area of such penetrations does not exceed 44,500 mm² (100 square inches) in any 100 square feet (9.29 m²) of ceiling area, and the annular space between the ceiling membrane and the box does not exceed 3.2 mm (1/8 inch).

3. Membrane penetrations by electrical boxes of any size or type that have been listed as part of an opening protective material system for use in horizontal assemblies and are installed in accordance with the instructions included in the listing.

4. Membrane penetrations by listed electrical boxes of any material, provided that such boxes have been tested for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the listing. The annular space between the ceiling membrane...
and the box shall not exceed 3.2 mm (1/8 inch) unless listed otherwise.

5. The annular space created by the penetration of a fire sprinkler, provided that it is covered by a metal escutcheon plate.

6. Noncombustible items that are cast into concrete building elements and that do not penetrate both top and bottom surfaces of the element.

7. The ceiling membrane of 1- and 2-hour fire-resistance-rated horizontal assemblies is permitted to be interrupted with the double wood top plate of a wall assembly that is sheathed with Type X gypsum wallboard, provided that all penetrating items through the double top plates are protected in accordance with Clause 8.14.5.1.1 or 8.14.5.1.2 and the ceiling membrane is tight to the top plates.

8. Ceiling membrane penetrations by listed luminaires (light fixtures) or by luminaires protected with listed materials, which have been tested for use in fire-resistance-rated assemblies and are installed in accordance with the instructions included in the listing.

8.14.5.3 Dissimilar materials.

Noncombustible penetrating items shall not connect to combustible materials beyond the point of firestopping unless it can be demonstrated that the fire-resistance integrity of the horizontal assembly is maintained.

8.14.5.4 Penetrations in smoke barriers.

Penetrations in smoke barriers shall be protected by an approved through-penetration firestop system installed and tested in accordance with the requirements of UL 1479 for air leakage. The L rating of the system measured at 7.47 Pa (0.30 inch) of water in both the ambient temperature and elevated temperature tests shall not exceed either of the following:

1. 0.025 m³/s · m² (5.0 cfm per square foot) of penetration opening for each through-penetration firestop system.

2. A total cumulative leakage of 50 cfm (0.024 m³/s) for any 9.3m² (100 square feet) of wall area, or floor area.

8.14.6 Nonfire-resistance-rated assemblies.

Penetrations of nonfire-resistance-rated floor or floor/ceiling assemblies or the ceiling membrane of a nonfire-resistance-rated roof/ceiling assembly shall meet the requirements of Clause 8.13 or shall comply with Clause 8.14.6.1 or 8.14.6.2.

8.14.6.1 Noncombustible penetrating items.

Noncombustible penetrating items that connect not more than five stories are permitted, provided that the annular space is filled to resist the free passage of flame and the products of combustion with an approved noncombustible material or with a fill, void or cavity material that is tested and classified for use in through-penetration firestop systems.

8.14.6.2 Penetrating items.

Penetrating items that connect not more than two stories are permitted, provided that the annular space is filled with an approved material to resist the free passage of flame and the products of combustion.

8.15 FIRE-RESISTANT JOINT SYSTEMS

8.15.1 General.

Joints installed in or between fire-resistance-rated walls, floor or floor/ceiling assemblies and roofs or roof/ceiling assemblies shall be protected by an approved fire-resistant joint system designed to resist the passage of fire for a time period not less than the required fire-resistance rating of the wall, floor or roof in or between which the system is installed. Fire-resistant joint systems shall be tested in accordance with Clause 8.15.3.

Exception: Fire-resistant joint systems shall not be required for joints in all of the following locations:

1. Floors within a single dwelling unit.
2. Floors where the joint is protected by a shaft enclosure in accordance with Clause 8.13.

3. Floors within atriums where the space adjacent to the atrium is included in the volume of the atrium for smoke control purposes.

4. Floors within malls.

5. Floors and ramps within parking garages or structures constructed in accordance with Clause 4.6.5 and 4.6.6.


7. Walls that are permitted to have unprotected openings.

8. Roofs where openings are permitted.

9. Control joints not exceeding a maximum width of 15.9 mm (0.625 inch) and tested in accordance with ASTM E119.

10. The interclause of exterior curtain wall assemblies and the roof slab or roof deck.

8.15.1.1 Curtain wall assembly.

The void created at the interclause of a floor/ceiling assembly and an exterior curtain wall assembly shall be protected in accordance with Clause 8.15.4.

8.15.2 Installation.

A fire-resistant joint system shall be securely installed in accordance with the manufacturer’s installation instructions and the listing criteria in or on the joint for its entire length so as not to impair its ability to accommodate expected building movements and to resist the passage of fire and hot gases.

8.15.3 Fire test criteria.

Fire-resistant joint systems shall be tested in accordance with the requirements of either ASTM E1966. Nonsymmetrical wall joint systems shall be tested with both faces exposed to the furnace, and the assigned fire-resistance rating shall be the shortest duration obtained from the two tests. Where evidence is furnished to show that the wall was tested with the least fire-resistant side exposed to the furnace, subject to acceptance of the building official, the wall need not be subjected to tests from the opposite side.

**Exception:** For exterior walls with a horizontal fire separation distance greater than 10 feet (3048 mm), the joint system shall be required to be tested for interior fire exposure only.

8.15.4 Exterior curtain wall/floor interclause.

Where fire-resistance-rated floor or floor/ceiling assemblies are required, voids created at the interclause of the exterior curtain wall assemblies and such floor assemblies shall be sealed with an approved system to prevent the interior spread of fire. Such systems shall be securely installed and tested in accordance with ASTM E2307 to provide an F rating for a time period not less than the fire-resistance rating of the floor assembly. Height and fire-resistance requirements for curtain wall spandrels shall comply with Clause 8.5.8.5.

**Exception:** Voids created at the interclause of the exterior curtain wall assemblies and such floor assemblies where the vision glass extends to the finished floor level shall be permitted to be sealed with an approved material to prevent the interior spread of fire. Such material shall be securely installed and capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste where subjected to ASTM E119 time-temperature fire conditions under a minimum positive pressure differential of 0.01 inch (0.254 mm) of water column (2.5 Pa) for the time period not less than the fire-resistance rating of the floor assembly.

8.15.4.1 Exterior curtain wall/nonfire-resistance-rated floor assembly interclauses.

Voids created at the interclause of exterior curtain wall assemblies and nonfire-resistance-rated floor or floor/ceiling assemblies shall be sealed with an approved material or system to retard the interior spread of fire and hot gases between stories.

8.15.4.2 Exterior curtain wall/vertical fire barrier interclauses.

Voids created at the interclause of nonfire-resistance-rated exterior curtain wall
8.15.5 Spandrel wall.

Height and fire-resistance requirements for curtain wall spandrels shall comply with Clause 8.5.8.5. Where Clause 8.5.8.5 does not require a fire-resistance-rated spandrel wall, the requirements of this Code shall still apply to the interclause between the spandrel wall and the floor.

8.15.6 Fire-resistant joint systems in smoke barriers.

Fire-resistant joint systems in smoke barriers, and joints at the interclause of a horizontal smoke barrier and an exterior curtain wall, shall be tested in accordance with the requirements of UL 2079 for air leakage. The L rating of the joint system shall not exceed 0.00775 m³/s m (5 cfm per linear foot) of joint at 7.47 Pa (0.30 inch) of water for both the ambient temperature and elevated temperature tests.

8.16 OPENING PROTECTIVES

### 8.16.1 General.

Opening protectives required by other clauses of this Code shall comply with the provisions of this clause and shall be installed in accordance with this Code.

<table>
<thead>
<tr>
<th>TABLE 8.16.1(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARKING FIRE-RATED GLAZING ASSEMBLIES</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIRE TEST STANDARD</th>
<th>MARKING</th>
<th>DEFINITION OF MARKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM E119</td>
<td>W</td>
<td>Meets wall assembly criteria.</td>
</tr>
<tr>
<td>ASTM E119</td>
<td>FC</td>
<td>Meets floor/ceiling criteria.</td>
</tr>
<tr>
<td>Ghana Fire Code</td>
<td>OH</td>
<td>Meets fire window assembly criteria including the hose stream test.</td>
</tr>
<tr>
<td></td>
<td>D H T</td>
<td>Meets fire door assembly criteria. Meets fire door assembly hose stream test. Meets 450°F temperature rise criteria for 30 minutes</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>The time in minutes of the fire resistance or fire protection rating of the glazing assembly.</td>
</tr>
</tbody>
</table>

**Note:** For SI: °C = [(°F) - 32]/1.8.

**a.** See Clause 25.9

<table>
<thead>
<tr>
<th>TABLE 8.16.1(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPENING FIRE PROTECTION ASSEMBLIES, RATINGS AND MARKINGS</td>
</tr>
</tbody>
</table>

assemblies and fire barriers shall be filled. An approved material or system shall be used to fill the void and shall be securely installed in or on the interclause for its entire length so as not to dislodge, loosen or otherwise impair its ability to accommodate expected building movements and to retard the passage of fire and hot gases.
<table>
<thead>
<tr>
<th>TYPE OF ASSEMBLY</th>
<th>REQUIRED WALL ASSEMBLY RATING (hours)</th>
<th>MINIMUM FIRE DOOR AND FIRE SHUTTER ASSEMBLY RATING (hours)</th>
<th>DOOR VISION PANEL SIZE</th>
<th>FIRE-RATED GLAZING MARKING DOOR VISION PANEL</th>
<th>MINIMUM SIDELIGHT/TRANSOM ASSEMBLY RATING (hours)</th>
<th>FIRE-RATED GLAZING MARKING SIDELIGHT/TRANSOM PANEL</th>
<th>FIRE PROTECTION</th>
<th>FIRE RESISTANCE</th>
<th>FIRE PROTECTION</th>
<th>FIRE RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire walls and fire barriers having a required fire-resistance rating greater than 1 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire walls and fire barriers having a required fire-resistance rating greater than 1 hour</td>
<td>4</td>
<td>3</td>
<td>See Note b</td>
<td>D-H-W-240</td>
<td>Not Permitted</td>
<td>4</td>
<td>Not Permitted</td>
<td>W-240</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3a</td>
<td>See Note b</td>
<td>D-H-W-180</td>
<td>Not Permitted</td>
<td>3</td>
<td>Not Permitted</td>
<td>W-180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 1/2</td>
<td>100 sq. in.</td>
<td>≤ 100 sq. in. = D-H-90 &gt; 100 sq. in. = D-H-W-90</td>
<td>Not Permitted</td>
<td>2</td>
<td>Not Permitted</td>
<td>W-120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/2</td>
<td>1 1/2</td>
<td>100 sq. in.</td>
<td>≤ 100 sq. in. = D-H-90 &gt; 100 sq. in. = D-H-W-90</td>
<td>Not Permitted</td>
<td>1 1/2</td>
<td>Not Permitted</td>
<td>W-90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical exits in fire wallsd</td>
<td>2</td>
<td>1 1/2</td>
<td>100 sq. in.</td>
<td>≤ 100 sq. in. = D-H-90 &gt; 100 sq. in. = D-H-T-W-90</td>
<td>Not Permitted</td>
<td>2</td>
<td>Not Permitted</td>
<td>W-120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal exits in fire walls</td>
<td>4</td>
<td>3</td>
<td>100 sq. in.</td>
<td>≤ 100 sq. in. = D-H-180 &gt; 100 sq. in. = D-H-W-240</td>
<td>Not Permitted</td>
<td>4</td>
<td>Not Permitted</td>
<td>W-240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3a</td>
<td>100 sq. in.</td>
<td>≤ 100 sq. in. = D-H-180 &gt; 100 sq. in. = D-H-W-180</td>
<td>Not Permitted</td>
<td>3</td>
<td>Not Permitted</td>
<td>W-180</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire barriers having a required fire-resistance rating of 1 hour: Enclosures for shafts, exit access stairways, exit access ramps, interior exit stairways and interior exit ramps; and exit passageway walls</td>
<td>1</td>
<td>1</td>
<td>100 sq. in.</td>
<td>≤ 100 sq. in. = D-H-60 &gt; 100 sq. in. = D-H-T-W-60</td>
<td>Not Permitted</td>
<td>1</td>
<td>Not Permitted</td>
<td>W-60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fire protection

<table>
<thead>
<tr>
<th>Other fire barriers</th>
<th>1</th>
<th>1/4</th>
<th>Maximum size tested</th>
<th>D-H</th>
<th>1/4</th>
<th>D-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire partitions. Corridor walls</td>
<td>1</td>
<td>1/3</td>
<td>Maximum size tested</td>
<td>D-20</td>
<td>1/3</td>
<td>D-H-OH-45</td>
</tr>
<tr>
<td>0.5</td>
<td>1/3</td>
<td>Maximum size tested</td>
<td>D-20</td>
<td>1/3</td>
<td>D-H-OH-20</td>
<td></td>
</tr>
<tr>
<td>Other fire partitions</td>
<td>1</td>
<td>1/4</td>
<td>Maximum size tested</td>
<td>D-H-45</td>
<td>1/4</td>
<td>D-H-45</td>
</tr>
<tr>
<td>0.5</td>
<td>1/3</td>
<td>Maximum size tested</td>
<td>D-H-20</td>
<td>1/3</td>
<td>D-H-20</td>
<td></td>
</tr>
</tbody>
</table>

(continued)

TABLE 8.16.1(2)—continued
OPENING FIRE PROTECTION ASSEMBLIES, RATINGS AND MARKINGS

242
a. Two doors, each with a fire protection rating of 11/2 hours, installed on opposite sides of the same opening in a fire wall, shall be deemed equivalent in fire protection rating to one 3-hour fire door.
b. Fire-resistance-rated glazing tested to ASTM E119 in accordance with Clause 8.16.1.2.3 shall be permitted, in the maximum size tested.
c. Under the column heading “Fire-rated glazing marking door vision panel,” W refers to the fire-resistance rating of the glazing, not the frame.
d. See Clause 8.16.2.5.1.2.1.
e. See Clause 8.16.1.2.2.1 and Table 8.16.1(1) for additional permitted markings.

### Table 8.16.1(3)

**FIRE WINDOW ASSEMBLY FIRE PROTECTION RATINGS**

<table>
<thead>
<tr>
<th>TYPE OF WALL ASSEMBLY</th>
<th>REQUIRED WALL ASSEMBLY RATING (hours)</th>
<th>MINIMUM FIRE WINDOW ASSEMBLY RATING (hours)</th>
<th>FIRE-RATED GLAZING MARKING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interior walls</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire walls</td>
<td>All</td>
<td>NP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>W-XXX&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fire barriers</td>
<td>&gt;1</td>
<td>NP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>W-XXX&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Atrium separations (Clause 8.7.3.6), Incidental use areas (Clause 8.7.3.7), Mixed occupancy separations (Clause 8.7.3.9)</td>
<td>1</td>
<td>3/4</td>
<td>OH-45 or W-60</td>
</tr>
<tr>
<td>Fire partitions</td>
<td>1</td>
<td>3/4</td>
<td>OH-45 or W-60</td>
</tr>
<tr>
<td>Smoke barriers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>1/3</td>
<td>OH-20 or W-30</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3/4</td>
<td>OH-45 or W-60</td>
</tr>
<tr>
<td><strong>Exterior walls</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>&gt;1</td>
<td>1/2</td>
<td>OH-90 or W-XXX&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3/2</td>
<td>OH-45 or W-60</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>1/3</td>
<td>OH-20 or W-30</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3/4</td>
<td>OH-45 or W-60</td>
</tr>
<tr>
<td><strong>Party wall</strong></td>
<td>All</td>
<td>NP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

**Notes:**
- NP = Not Permitted.
- W-XXX = The fire rating duration period in minutes, which shall be equal to the fire-resistance rating required for the wall assembly.
8.16.1.1 Alternative methods for determining fire protection ratings.

The application of any of the alternative methods listed in this clause shall be based on the fire exposure and acceptance criteria specified in the Ghana Fire Code. The required fire resistance of an opening protective shall be permitted to be established by any of the following methods or procedures:

1. Designs documented in approved sources.
2. Calculations performed in an approved manner.
3. Engineering analysis based on a comparison of opening protective designs having fire protection ratings as determined by the test procedures set forth in the Ghana Fire Code.
4. Alternative protection methods as allowed by Clause 11.4.11.

8.16.1.2 Glazing.

Glazing used in fire door assemblies and fire window assemblies shall comply with this clause in addition to the requirements of Clauses 8.16.2 and 8.16.3, respectively.

8.16.1.2.1 Safety glazing.

Fire-protection-rated glazing and fire-resistance-rated glazing installed in fire door assemblies and fire window assemblies shall comply with the safety glazing requirements of Part 25 where applicable.

8.16.1.2.2 Marking fire-rated glazing assemblies.

Fire-rated glazing assemblies shall be marked in accordance with Tables 8.16.1(1), 8.16.1(2) and 8.16.1(3).

8.16.1.2.2.1 Fire-rated glazing identification.

For fire-rated glazing, the label shall bear the identification required in Tables 8.16.1(1) and 8.16.1(2). “D” indicates that the glazing is permitted to be used in fire door assemblies and meets the fire protection requirements of the Ghana Fire Code. “H” indicates that the glazing meets the hose stream requirements of the Ghana Fire Code. “T” indicates that the glazing meets the temperature requirements of Clause 8.16.2.2.3.1. The placeholder “XXX” represents the fire-rating period, in minutes.

8.16.1.2.2.2 Fire-protection-rated glazing identification.

For fire-protection-rated glazing, the label shall bear the following identification required in Tables 8.16.1(1) and 8.16.1(3): “OH – XXX.” “OH” indicates that the glazing meets both the fire protection and the hose-stream requirements of the Ghana Fire Code and is permitted to be used in fire window openings. The placeholder “XXX” represents the fire-rating period, in minutes.

8.16.1.2.2.3 Fire-resistance-rated glazing identification.

For fire-resistance-rated glazing, the label shall bear the identification required in Clause 8.03.6 and Table 8.16.1(1).

8.16.1.2.2.4 Fire-rated glazing that exceeds the Code requirements.

Fire-rated glazing assemblies marked as complying with hose stream requirements (H) shall be permitted in applications that do not require compliance with hose stream requirements. Fire-rated glazing assemblies marked as complying with temperature rise requirements (T) shall be permitted in applications that do not require compliance with temperature rise requirements. Fire-rated glazing assemblies marked with ratings (XXX) that exceed the ratings required by this Code shall be permitted.

8.16.1.2.3 Fire-resistance-rated glazing.

Fire-rated glazing tested as part of a fire-resistance-rated wall or floor/ceiling assembly in accordance with ASTM E119 and labeled in accordance with Clause 8.3.6 shall otherwise be required to comply with this clause where used as part of a wall or floor/ceiling assembly.
8.16.1.2.3.1 Glazing in fire door and fire window assemblies.

Fire-resistance-rated glazing shall be permitted in fire door and fire window assemblies where tested and installed in accordance with their listings and where in compliance with the requirements of this clause.

8.16.2 Fire door assemblies.

Fire door assemblies required by other clauses of this Code shall comply with the provisions of this clause. Fire door frames with transom lights, sidelights or both shall be permitted in accordance with Clause 8.16.2.5.4.

8.16.2.1 Testing requirements.

Approved fire door and fire shutter assemblies shall be constructed of any material or assembly of component materials that conforms to the test requirements of Clauses 8.16.2.1.1 through 8.16.2.1.4 and the fire protection rating indicated in Table 8.16.1(2).

Exceptions:

1. Labeled protective assemblies that conform to the requirements of this clause for tin-clad fire door assemblies.

2. Floor fire door assemblies in accordance with Clause 8.12.1.13.1.

8.16.2.1.1 Side-hinged or pivoted swinging doors.

Fire door assemblies with side-hinged and pivoted swinging doors shall be tested in accordance with the Ghana Fire Code. For tests conducted in accordance with the Ghana Fire Code, the fire test shall be conducted using the positive pressure method specified in the standard.

8.16.2.1.2 Other types of assemblies.

Fire door assemblies with other types of doors, including swinging elevator doors, horizontal sliding fire doors, rolling steel fire doors, fire shutters, bottom- and side-hinged chute intake doors, and top-hinged chute discharge doors, shall be tested in accordance with the Ghana Fire Code. For tests conducted in accordance with the Ghana Fire Code, the neutral pressure plane in the furnace shall be maintained as nearly equal to the atmospheric pressure as possible at the top of the door, as specified in the standard.

8.16.2.1.3 Glazing in transoms lights and sidelights in corridors and smoke barriers.

Glazing material in any other part of the door assembly, including transom lights and sidelights, shall be tested in accordance with the Ghana Fire Code, including the hose stream test, in accordance with Clause 8.16.3.1.1.

8.16.2.1.4 Smoke and draft control.

Fire door assemblies that serve as smoke and draft control assemblies shall be tested in accordance with this Code.

8.16.2.2 Performance requirements.

Fire door assemblies shall be installed in the assemblies specified in Table 8.16.1(2) and shall comply with the fire protection rating specified.

8.16.2.2.1 Door assemblies in corridors and smoke barriers.

Fire door assemblies required to have a minimum fire protection rating of 20 minutes where located in corridor walls or smoke barrier walls having a fire-resistance rating in accordance with Table 8.16.1(2) shall be tested in accordance with the Ghana Fire Code, without the hose stream test.

Exceptions:

1. Viewports that require a hole not larger than 25 mm (1 inch) in diameter through the door, have not less than a 6.4 mm (0.25-inch-thick) glass disc and the holder is of metal that will not melt out where subject to temperatures of 927°C (1,700°F).

2. Corridor door assemblies in occupancies of Group I-2 shall be in accordance with Clause 4.7.3.1.

3. Unprotected openings shall be permitted for corridors in multitheater
complexes where each motion picture auditorium has not less than one-half of its required exit or exit access doorways opening directly to the exterior or into an exit passageway.

4. Horizontal sliding doors in smoke barriers that comply with Clauses 4.8.6 and 4.8.8.4 in occupancies in Group I-3.

8.16.2.2.1.1 Smoke and draft control.

The air leakage rate of the door assembly shall not exceed 3.0 cubic feet per minute per square foot (0.01524 m³/s × m²) of door opening at 0.10 inch (24.9 Pa) of water for both the ambient temperature and elevated temperature tests. Louvers shall be prohibited.

8.16.2.2 Door assemblies in other fire partitions.

Fire door assemblies required to have a minimum fire protection rating of 20 minutes where located in other fire partitions having a fire-resistance rating of 0.5 hour in accordance with Table 8.16.1(2) shall be tested in accordance with the Ghana Fire Code, with the hose stream test.

8.16.2.2.3 Doors in interior exit stairways and ramps and exit passageways.

Fire door assemblies in interior exit stairways and ramps and exit passageways shall have a maximum transmitted temperature rise of not more than 250°C (450°F) above ambient at the end of 30 minutes of standard fire test exposure.

Exception: The maximum transmitted temperature rise is not required in buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

8.16.2.2.3.1 Glazing in doors.

Fire-protection-rated glazing in excess of 100 square inches (0.065 m²) is not permitted. Fire-resistance-rated glazing in excess of 0.065 m² (100 square inches) shall be permitted in fire doors. Listed fire-resistance-rated glazing in a fire door shall have a maximum transmitted temperature rise in accordance with Clause 8.16.2.2.3 when the fire door is tested in accordance with the Ghana Fire Code.

8.16.2.3 Fire doors.

Fire doors installed within a fire door assembly shall meet the fire rating indicated in Table 8.16.1(2).

8.16.2.4 Fire door frames.

Fire door frames installed as part of a fire door assembly shall meet the fire rating indicated in Table 8.16.1(2).

8.16.2.5 Glazing in fire door assemblies.

Fire-rated glazing conforming to the opening protection requirements in Clause 8.16.2.1 shall be permitted in fire door assemblies.

8.16.2.5.1 Size limitations.

Fire-resistance-rated glazing shall comply with the size limitations in Clause 8.16.2.5.1.1. Fire-protection-rated glazing shall comply with the size limitations of the Ghana Fire Code, and as provided in Clause 8.16.2.5.1.2.

8.16.2.5.1.1 Fire-resistance-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.

Fire-resistance-rated glazing tested to ASTM E119 shall be permitted in fire door assemblies located in fire walls and in fire barriers in accordance with Table 8.16.1(2) to the maximum size tested and in accordance with their listings.

8.16.2.5.1.2 Fire-protection-rated glazing in door assemblies in fire walls and fire barriers rated greater than 1 hour.

Fire-protection-rated glazing shall be prohibited in fire walls and fire barriers except as provided in Clauses 8.16.2.5.1.2.1 and 8.16.2.5.1.2.2.

8.16.2.5.1.2.1 Horizontal exits.

Fire-protection-rated glazing shall be permitted as vision panels in self-closing swinging fire door assemblies serving as horizontal exits in fire walls where limited to 0.065 m² (100 square inches).
8.16.2.5.1.2.2 Fire barriers.

Fire-protection-rated glazing shall be permitted in fire doors having a 1 1/2-hour fire protection rating intended for installation in fire barriers, where limited to 0.065 m² (100 square inches).

8.16.2.5.2 Elevator, stairway and ramp protective.

Approved fire-protection-rated glazing used in fire door assemblies in elevator, stairway and ramp enclosures shall be so located as to furnish clear vision of the passageway or approach to the elevator, stairway or ramp.

8.16.2.5.3 Glazing in door assemblies in corridors and smoke barriers.

In a 20-minute fire door assembly, the glazing material in the door itself shall have a minimum fire-protection-rated glazing of 20 minutes and shall be exempt from the hose stream test.

8.16.2.5.4 Fire door frames with transom lights and sidelights.

Fire-protection-rated glazing shall be permitted in door frames with transom lights, sidelights or both, where a 3/4-hour fire protection rating or less is required and in 2-hour fire-resistance-rated exterior walls in accordance with Table 8.16.1(2). Fire door frames with transom lights, sidelights, or both, installed with fire-resistance-rated glazing tested as an assembly in accordance with ASTM E119 shall be permitted where a fire protection rating exceeding 3/4 hour is required in accordance with Table 8.16.1(2).

8.16.2.6 Fire door hardware and closures.

Fire door hardware and closures shall be installed on fire door assemblies in accordance with the requirements of this clause.

8.16.2.6.1 Door closing.

Fire doors shall be latching and self- or automatic-closing in accordance with this clause.

Exceptions:

1. Fire doors located in common walls separating sleeping units in Group R-1 shall be permitted without automatic- or self-closing devices.

2. The elevator car doors and the associated hoistway enclosure doors at the floor level designated for recall in accordance with this Code shall be permitted to remain open during Phase I emergency recall operation.

8.16.2.6.2 Latch required.

Unless otherwise specifically permitted, single side-hinged swinging fire doors and both leaves of pairs of side-hinged swinging fire doors shall be provided with an active latch bolt that will secure the door when it is closed.

8.16.2.6.3 Chute intake door latching.

Chute intake doors shall be positive latching, remaining latched and closed in the event of latch spring failure during a fire emergency.

8.16.2.6.4 Automatic-closing fire door assemblies.

Automatic-closing fire door assemblies shall be self-closing in accordance with the Ghana Fire Code.

8.16.2.6.5 Delayed-action closers.

Doors required to be self-closing and not required to be automatic closing shall be permitted to be equipped with delayed-action closers.

8.16.2.6.6 Smoke-activated doors.

Automatic-closing doors installed in the following locations shall be permitted to have hold-open devices. Doors shall automatically close by the actuation of smoke detectors installed in accordance with Clause 10.7.3 or by loss of power to the smoke detector or hold-open device. Doors that are automatic-closing by smoke detection shall not have more than a 10-second delay before the door starts to close after the smoke detector is actuated. Automatic-closing doors that protect openings installed in the following locations shall comply with this clause:
1. In walls that separate incidental uses in accordance with this Code.

2. In fire walls in accordance with Clause 8.6.8.

3. In fire barriers in accordance with Clause 8.7.6.

4. In fire partitions in accordance with Clause 8.8.6.

5. In smoke barriers in accordance with Clause 8.9.5.

6. In smoke partitions in accordance with Clause 8.10.5.2.3.

7. In shaft enclosures in accordance with Clause 8.13.7.

8. In waste and linen chutes, discharge openings and access and discharge rooms in accordance with Clause 8.13.13. Loading doors installed in waste and linen chutes shall meet the requirements of Clauses 8.16.2.6.1 and 8.16.2.6.3.

8.16.2.6.7 Doors in pedestrian ways.

Vertical sliding or vertical rolling steel fire doors in openings through which pedestrians travel shall be heat activated or activated by smoke detectors with alarm verification.

8.16.2.7 Swinging fire shutters.

Where fire shutters of the swinging type are installed in exterior openings, not less than one row in every three vertical rows shall be arranged to be readily opened from the outside, and shall be identified by distinguishing marks or letters not less than 152 mm (6 inches) high.

8.16.2.8 Rolling fire shutters.

Where fire shutters of the rolling type are installed, such shutters shall include approved automatic-closing devices.

8.16.2.9 Labeled protective assemblies.

Fire door assemblies shall be labeled by an approved agency. The labels shall comply with the Ghana Fire Code, and shall be permanently affixed to the door or frame.

8.16.2.9.1 Fire door labeling requirements.

Fire doors shall be labeled showing the name of the manufacturer or other identification readily traceable back to the manufacturer, the name or trademark of the third-party inspection agency, the fire protection rating and, where required for fire doors in interior exit stairways and ramps and exit passageways by Clause 8.16.2.2.3, the maximum transmitted temperature end point. Smoke and draft control doors complying with this Code shall be labeled as such and shall comply with Clause 8.16.2.9.3. Labels shall be approved and permanently affixed. The label shall be applied at the factory or location where fabrication and assembly are performed.

8.16.2.9.1.1 Light kits, louvers and components.

Listed light kits and louvers and their required preparations shall be considered as part of the labeled door where such installations are done under the listing program of the third-party agency. Fire doors and fire door assemblies shall be permitted to consist of components, including glazing, vision light kits and hardware that are listed or classified and labeled for such use by different third-party agencies.

8.16.2.9.2 Oversized doors.

Oversized fire doors shall bear an oversized fire door label by an approved agency or shall be provided with a certificate of inspection furnished by an approved testing agency. Where a certificate of inspection is furnished by an approved testing agency, the certificate shall state that the door conforms to the requirements of design, materials and construction, but has not been subjected to the fire test.

8.16.2.9.3 Smoke and draft control door labeling requirements.

Smoke and draft control doors complying with this Code shall be labeled in accordance with Clause 8.16.2.9.1 and shall show the letter “S” on the fire-rating label of the door. This marking shall indicate that the door and frame assembly are in compliance where listed or labeled gasketing is installed.
8.16.2.9.4 Fire door frame labeling requirements.
Fire door frames shall be labeled showing the names of the manufacturer and the third-party inspection agency.

8.16.2.9.5 Labeling.
Fire-rated glazing shall bear a label or other identification showing the name of the manufacturer, the test standard and information required in Table 716.1(1) that shall be issued by an approved agency and shall be permanently identified on the glazing.

8.16.2.9.6 Fire door operator labeling requirements.
Fire door operators for horizontal sliding doors shall be labeled and listed for use with the assembly.

8.16.2.10 Installation of door assemblies in corridors and smoke barriers.
Installation of smoke doors shall be in accordance with the Ghana Fire Code.

8.16.3 Fire window assemblies.
Fire window assemblies required by other clauses of this Code shall comply with the provisions of this clause.

8.16.3.1 Testing requirements.
Fire window assemblies shall be constructed of any material or assembly of component materials that conforms to the test requirements of Clauses 8.16.3.1.1 and 8.16.3.1.2 and the fire protection rating indicated in Table 8.16.1(3).

8.16.3.1.1 Testing under positive pressure.
The Ghana Fire Code shall evaluate fire-protection-rated glazing under positive pressure. Within the first 10 minutes of a test, the pressure in the furnace shall be adjusted so not less than two-thirds of the test specimen is above the neutral pressure plane, and the neutral pressure plane shall be maintained at that height for the balance of the test.

8.16.3.1.2 Nonsymmetrical glazing systems.
Nonsymmetrical fire-protection-rated glazing systems in fire partitions, fire barriers or in exterior walls with a fire separation distance of 10 feet (3048 mm) or less pursuant to Clause 8.5 shall be tested with both faces exposed to the furnace, and the assigned fire protection rating shall be the shortest duration obtained from the two tests conducted in compliance with the Ghana Fire Code.

8.16.3.2 Performance requirements.
Fire window assemblies shall be installed in the assemblies and comply with the fire protection rating specified in Table 8.16.1(3).

8.16.3.2.1 Interior fire window assemblies.
Fire-protection-rated glazing used in fire window assemblies located in fire partitions and fire barriers shall be limited to use in assemblies with a maximum fire-resistance rating of 1 hour in accordance with this clause.

8.16.3.2.1.1 Where 3/4-hour-fire-protection window assemblies permitted.
Fire-protection-rated glazing requiring 45-minute opening protection in accordance with Table 8.16.1(3) shall be limited to fire partitions designed in accordance with Clause 8.8 and fire barriers utilized in the applications set forth in Clauses 8.7.3.6, 8.7.3.7 and 8.7.3.9 where the fire-resistance rating does not exceed 1 hour. Fire-resistance-rated glazing assemblies tested in accordance with ASTM E119 shall not be subject to the limitations of this clause.

8.16.3.2.1.2 Area limitations.
The total area of the glazing in fire-protection-rated window assemblies shall not exceed 25 percent of the area of a common wall with any room.

8.16.3.2.1.3 Where 1/3-hour-fire-protection window assemblies permitted.
Fire-protection-rated glazing shall be permitted in window assemblies tested to the Ghana Fire Code in fire partitions requiring 1/3-hour opening protection in accordance with Table 8.16.1(3).
8.16.3.3 Fire window frames.

Fire window frames installed with a fire window assembly shall meet the fire-protection rating indicated in Table 8.16.1(3).

8.16.3.3.1 Window mullions.

Metal mullions that exceed a nominal height of 12 feet (3658 mm) shall be protected with materials to afford the same fire-resistance rating as required for the wall construction in which the protective is located.

8.16.3.4 Fire-protection-rated glazing.

Glazing in fire window assemblies shall be fire protection rated in accordance with this clause and Table 8.16.1(3). Fire-protection-rated glazing in fire window assemblies shall be tested in accordance with and shall meet the acceptance criteria of the Ghana Fire Code. Openings in nonfire-resistance-rated exterior wall assemblies that require protection in accordance with Clause 8.5.3, 8.5.8, 8.5.8.5 or 8.5.8.6 shall have a fire protection rating of not less than 3/4 hour. Fire-protection-rated glazing in 1/2-hour fire-resistance-rated partitions is permitted to have a 20-minute fire protection rating.

8.16.3.4.1 Glass and glazing.

Glazing in fire window assemblies shall be fire-protection-rated glazing installed in accordance with and complying with the size limitations set forth in the Ghana Fire Code.

8.16.3.5 Labeled protective assemblies.

Glazing in fire window assemblies shall be labeled by an approved agency. The labels shall comply with Clause 8.16.3.5.2.

8.16.3.5.1 Fire window frames.

Fire window frames shall be approved for the intended application.

8.16.3.5.2 Labeling requirements.

Fire-protection-rated glazing shall bear a label or other identification showing the name of the manufacturer, the test standard and information required in Clause 8.16.1.2.2.2 and Table 8.16.1(3) that shall be issued by an approved agency and permanently identified on the glazing.

8.16.3.6 Installation.

Fire window assemblies shall be installed in accordance with the provisions of this clause.

8.16.3.6.1 Closure.

Fire-protection-rated glazing shall be in the fixed position or be automatic-closing and shall be installed in labeled frames.

8.17 DUCTS AND AIR TRANSFER OPENINGS

8.17.1 General.

The provisions of this clause shall govern the protection of duct penetrations and air transfer openings in assemblies required to be protected and duct penetrations in nonfire-resistance-rated floor assemblies.

8.17.1.1 Ducts and air transfer openings.

Ducts transitioning horizontally between shafts shall not require a shaft enclosure provided that the duct penetration into each associated shaft is protected with dampers complying with this clause.

8.17.1.2 Ducts that penetrate fire-resistance-rated assemblies without dampers.

Ducts that penetrate fire-resistance-rated walls and are not required by this clause to have fire dampers shall comply with the requirements of Clauses 8.14.3 through 8.14.4.3. Ducts that penetrate horizontal assemblies not required to be contained within a shaft and not required by this clause to have fire dampers shall comply with the requirements of Clauses 8.14.5 through 8.14.6.2.
8.17.1.2.1 Ducts that penetrate nonfire-resistance-rated assemblies.

The space around a duct penetrating a nonfire-resistance-rated floor assembly shall comply with Clause 8.17.6.3.

8.17.2 Installation.

Fire dampers, smoke dampers, combination fire/smoke dampers and ceiling radiation dampers located within air distribution and smoke control systems shall be installed in accordance with the requirements of this clause, the manufacturer's instructions and the dampers' listing.

8.17.2.1 Smoke control system.

Where the installation of a fire damper will interfere with the operation of a required smoke control system in accordance with Clause 10.9, approved alternative protection shall be utilized. Where mechanical systems including ducts and dampers utilized for normal building ventilation serve as part of the smoke control system, the expected performance of these systems in smoke control mode shall be addressed in the rational analysis required by Clause 10.9.4.

8.17.2.2 Hazardous exhaust ducts.

Fire dampers for hazardous exhaust duct systems shall comply with this Code.

8.17.3 Damper testing, ratings and actuation.

Damper testing, ratings and actuation shall be in accordance with Clauses 8.17.3.1 through 8.17.3.3.

8.17.3.1 Damper testing.

Dampers shall be listed and labeled in accordance with the standards in this clause.

1. Fire dampers shall comply with the requirements of this Code. Only fire dampers labeled for use in dynamic systems shall be installed in heating, ventilation and air-conditioning systems designed to operate with fans on during a fire.

2. Smoke dampers shall comply with the requirements of this Code.

3. Combination fire/smoke dampers shall comply with the requirements of this Code.

4. Ceiling radiation dampers shall comply with the requirements of this Code or shall be tested as part of a fire-resistance-rated floor/ceiling or roof/ceiling assembly in accordance with ASTM E119. Only ceiling radiation dampers labeled for use in dynamic systems shall be installed in heating, ventilation and air-conditioning systems designed to operate with fans on during a fire.

5. Corridor dampers shall comply with requirements of this Code. Corridor dampers shall demonstrate acceptable closure performance when subjected to 150 feet per minute (0.76 mps) velocity across the face of the damper during this Code fire exposure test.

8.17.3.2 Damper rating.

Damper ratings shall be in accordance with Clauses 8.17.3.2.1 through 8.17.3.2.4.

8.17.3.2.1 Fire damper ratings.

Fire dampers shall have the minimum rating specified in Table 8.17.3.2.1.

<table>
<thead>
<tr>
<th>TABLE 717.3.2.1</th>
</tr>
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<tbody>
<tr>
<td>FIRE DAMPER RATING</td>
</tr>
<tr>
<td>TYPE OF PENETRATION</td>
</tr>
<tr>
<td>Less than 3-hour fire-resistance-rated assemblies</td>
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<tr>
<td>3-hour or greater fire-resistance-rated assemblies</td>
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</table>
8.17.3.2.2 Smoke damper ratings.

Smoke damper leakage ratings shall be Class I or II. Elevated temperature ratings shall be not less than 250°F (121°C).

8.17.3.2.3 Combination fire/smoke damper ratings.

Combination fire/smoke dampers shall have the minimum rating specified for fire dampers in Table 717.3.2.1 and shall have the minimum rating specified for smoke dampers in Clause 8.17.3.2.2.

8.17.3.2.4 Corridor damper ratings.

Corridor dampers shall have the following minimum ratings:

1. One hour fire-resistance rating.
2. Class I or II leakage rating as specified in Clause 8.17.3.2.2.

8.17.3.3 Damper actuation.

Damper actuation shall be in accordance with Clauses 8.17.3.3.1 through 8.17.3.3.5 as applicable.

8.17.3.3.1 Fire damper actuation device.

The fire damper actuation device shall meet one of the following requirements:

1. The operating temperature shall be approximately 10°C (50°F) above the normal temperature within the duct system, but not less than 71°C (160°F).
2. The operating temperature shall be not more than 177°C (350°F) where located in a smoke control system complying with Clause 10.9.

8.17.3.3.2 Smoke damper actuation.

The smoke damper shall close upon actuation of a listed smoke detector or detectors installed in accordance with Clause 907.3 and one of the following methods, as applicable:

1. Where a smoke damper is installed within a duct, a smoke detector shall be installed inside the duct or outside the duct with sampling tubes protruding into the duct. The detector or tubes within the duct shall be within 5 feet (1524 mm) of the damper. Air outlets and inlets shall not be located between the detector or tubes and the damper. The detector shall be listed for the air velocity, temperature and humidity anticipated at the point where it is installed. Other than in mechanical smoke control systems, dampers shall be closed upon fan shutdown where local smoke detectors require a minimum velocity to operate.
2. Where a smoke damper is installed above smoke barrier doors in a smoke barrier, a spot-type detector shall be installed on either side of the smoke barrier door opening. The detector shall be listed for releasing service if used for direct interface with the damper.
3. Where a smoke damper is installed within an air transfer opening in a wall, a spot-type detector shall be installed within 5 feet (1524 mm) horizontally of the damper. The detector shall be listed for releasing service if used for direct interface with the damper.
4. Where a smoke damper is installed in a corridor wall or ceiling, the damper shall be permitted to be controlled by a smoke detection system installed in the corridor.
5. Where a smoke detection system is installed in all areas served by the duct in which the damper will be located, the smoke dampers shall be permitted to be controlled by the smoke detection system.

8.17.3.3.3 Combination fire/smoke damper actuation.

Combination fire/smoke damper actuation shall be in accordance with Clauses 8.17.3.3.1 and 8.17.3.3.2. Combination fire/smoke dampers installed in smoke control system shaft penetrations shall not be activated by local area smoke detection unless it is secondary to the smoke management system controls.
8.17.3.4 Ceiling radiation damper actuation.

The operating temperature of a ceiling radiation damper actuation device shall be 27.8°C (50°F) above the normal temperature within the duct system, but not less than 71°C (160°F).

8.17.3.5 Corridor damper actuation.

Corridor damper actuation shall be in accordance with Clauses 8.17.3.3.1 and 8.17.3.3.2.

8.17.4 Access and identification.

Fire and smoke dampers shall be provided with an approved means of access that is large enough to permit inspection and maintenance of the damper and its operating parts. The access shall not affect the integrity of fire-resistance-rated assemblies. The access openings shall not reduce the fire-resistance rating of the assembly. Access points shall be permanently identified on the exterior by a label having letters not less than 12.7 mm (1/2 inch) in height reading: FIRE/SMOKE DAMPER, SMOKE DAMPER or FIRE DAMPER. Access doors in ducts shall be tight fitting and suitable for the required duct construction.

8.17.5 Where required.

Fire, dampers, smoke dampers, combination fire/smoke dampers, ceiling radiation dampers and corridor dampers shall be provided at the locations prescribed in Clauses 8.17.5.1 through 8.17.5.7 and 8.17.6. Where an assembly is required to have both fire dampers and smoke dampers, combination fire/smoke dampers or a fire damper and a smoke damper shall be provided.

8.17.5.1 Fire walls.

Ducts and air transfer openings permitted in fire walls in accordance with Clause 8.8.11 shall be protected with listed fire dampers installed in accordance with their listing.

8.17.5.1.1 Horizontal exits.

A listed smoke damper designed to resist the passage of smoke shall be provided at each point a duct or air transfer opening penetrates a fire wall that serves as a horizontal exit.

8.17.5.2 Fire barriers.

Ducts and air transfer openings of fire barriers shall be protected with listed fire dampers installed in accordance with their listing. Ducts and air transfer openings shall not penetrate enclosures for interior exit stairways and ramps and exit passageways, except as permitted by Clauses 10.23.5 and 10.24.6, respectively.

Exception: Fire dampers are not required at penetrations of fire barriers where any of the following apply:

1. Penetrations are tested in accordance with ASTM E119 as part of the fire-resistance-rated assembly.
2. Ducts are used as part of an approved smoke control system in accordance with Clause 10.9 and where the use of a fire damper would interfere with the operation of a smoke control system.
3. Such walls are penetrated by ducted HVAC systems, have a required fire-resistance rating of 1 hour or less, are in areas of other than Group H and are in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2. For the purposes of this exception, a ducted HVAC system shall be a duct system for conveying supply, return or exhaust air as part of the structure’s HVAC system. Such a duct system shall be constructed of sheet steel not less than No. 26 gage thickness and shall be continuous from the air-handling appliance or equipment to the air outlet and inlet terminals.

8.17.5.2.1 Horizontal exits.

A listed smoke damper designed to resist the passage of smoke shall be provided at each point a duct or air transfer opening penetrates a fire barrier that serves as a horizontal exit.

8.17.5.3 Shaft enclosures.

Shaft enclosures that are permitted to be penetrated by ducts and air transfer openings shall be protected with listed fire and smoke dampers installed in accordance with their listing.
Exceptions:

1. Fire dampers are not required at penetrations of shafts where any of the following criteria are met:

   1.1. Steel exhaust subducts are extended not less than 22 inches (559 mm) vertically in exhaust shafts, provided that there is a continuous airflow upward to the outside.

   1.2. Penetrations are tested in accordance with ASTM E119 as part of the fire-resistance-rated assembly.

   1.3. Ducts are used as part of an approved smoke control system designed and installed in accordance with Clause 10.9 and where the fire damper will interfere with the operation of the smoke control system.

   1.4. The penetrations are in parking garage exhaust or supply shafts that are separated from other building shafts by not less than 2-hour fire-resistance-rated construction.

2. In Group B and R occupancies equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, smoke dampers are not required at penetrations of shafts where all of the following criteria are met:

   2.1. Kitchen, clothes dryer, bathroom and toilet room exhaust openings are installed with steel exhaust subducts, having a minimum wall thickness of 0.0187-inch (0.4712 mm) (No. 26 gage).

   2.2. The subducts extend not less than 559 mm (22 inches) vertically.

   2.3. An exhaust fan is installed at the upper terminus of the shaft that is powered continuously in accordance with the provisions of Clause 10.9.11, so as to maintain a continuous upward airflow to the outside.

3. Smoke dampers are not required at penetration of exhaust or supply shafts in parking garages that are separated from other building shafts by not less than 2-hour fire-resistance-rated construction.

4. Smoke dampers are not required at penetrations of shafts where ducts are used as part of an approved mechanical smoke control system designed in accordance with Clause 10.9 and where the smoke damper will interfere with the operation of the smoke control system.

5. Fire dampers and combination fire/smoke dampers are not required in kitchen and clothes dryer exhaust systems where dampers are prohibited by this Code.

8.17.5.4 Fire partitions.
Ducts and air transfer openings that penetrate fire partitions shall be protected with listed fire dampers installed in accordance with their listing.

Exceptions: In occupancies other than Group H, fire dampers are not required where any of the following apply:

1. Corridor walls in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and the duct is protected as a through penetration in accordance with Clause 8.14.

2. Tenant partitions in covered and open mall buildings where the walls are not required by provisions elsewhere in the Code to extend to the underside of the floor or roof sheathing, slab or deck above.

3. The duct system is constructed of approved materials in accordance with this Code and the duct penetrating the wall complies with all of the following requirements:

   3.1. The duct shall not exceed 0.06 m² (100 square inches).

   3.2. The duct shall be constructed of steel not less than 0.55 mm (0.0217 inch) in thickness.

   3.3. The duct shall not have openings that communicate the corridor with adjacent spaces or rooms.

   3.4. The duct shall be installed above a ceiling.

   3.5. The duct shall not terminate at a wall register in the fire-resistance-rated wall.

   3.6. A minimum 305 mm (12-inch-long) by 1.52 mm (0.060-inch-thick) steel sleeve shall be centered in each
duct opening. The sleeve shall be secured to both sides of the wall and all four sides of the sleeve with minimum 38 mm by 38 mm by 1.52 mm (1 1/2-inch by 1 1/2-inch by 0.060-inch) steel retaining angles. The retaining angles shall be secured to the sleeve and the wall with No. 10 (M5) screws. The annular space between the steel sleeve and the wall opening shall be filled with mineral wool batting on all sides.

4. Such walls are penetrated by ducted HVAC systems, have a required fire-resistance rating of 1 hour or less, and are in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2. For the purposes of this exception, a ducted HVAC system shall be a duct system for conveying supply, return or exhaust air as part of the structure’s HVAC system. Such a duct system shall be constructed of sheet steel not less than No. 26 gage thickness and shall be continuous from the air-handling appliance or equipment to the air outlet and inlet terminals.

8.17.5.4.1 Corridors.
Duct and air transfer openings that penetrate corridors shall be protected with dampers as follows:

1. A corridor damper shall be provided where corridor ceilings, constructed as required for the corridor walls as permitted in Clause 8.8.4, Exception 3, are penetrated.

2. A ceiling radiation damper shall be provided where the ceiling membrane of a fire-resistance-rated floor-ceiling or roof-ceiling assembly, constructed as permitted in Clause 8.8.4, Exception 2, is penetrated.

3. A listed smoke damper designed to resist the passage of smoke shall be provided at each point a duct or air transfer opening penetrates a corridor enclosure required to have smoke and draft control doors in accordance with Clause 8.16.2.2.1.

Exceptions:

1. Smoke dampers are not required where the building is equipped throughout with an approved smoke control system in accordance with Clause 10.9, and smoke dampers are not necessary for the operation and control of the system.

2. Smoke dampers are not required in corridor penetrations where the duct is constructed of steel not less than 0.019 inch (0.48 mm) in thickness and there are no openings serving the corridor.

8.17.5.5 Smoke barriers.
A listed smoke damper designed to resist the passage of smoke shall be provided at each point a duct or air transfer opening penetrates a smoke barrier. Smoke dampers and smoke damper actuation methods shall comply with Clause 8.17.3.3.2.

Exceptions:

1. Smoke dampers are not required where the openings in ducts are limited to a single smoke compartment and the ducts are constructed of steel.

2. Smoke dampers are not required in smoke barriers required by Clause 4.7.5 for Group I-2, Condition 2—where the HVAC system is fully ducted in accordance with Clause 7.3 of the International Mechanical Code and where buildings are equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 and equipped with quick-response sprinklers in accordance with Clause 10.3.3.2.

8.17.5.6 Exterior walls.
Ducts and air transfer openings in fire-resistance-rated exterior walls required to have protected openings in accordance with Clause 8.5.10 shall be protected with listed fire dampers installed in accordance with their listing.

8.17.5.7 Smoke partitions.
A listed smoke damper designed to resist the passage of smoke shall be provided at each
point that an air transfer opening penetrates a smoke partition. Smoke dampers and smoke damper actuation methods shall comply with Clause 8.17.3.3.2.

**Exception:** Where the installation of a smoke damper will interfere with the operation of a required smoke control system in accordance with Clause 10.9, approved alternative protection shall be utilized.

### 8.17.6 Horizontal assemblies.

Penetrations by ducts and air transfer openings of a floor, floor/ceiling assembly or the ceiling membrane of a roof/ceiling assembly shall be protected by a shaft enclosure that complies with Clause 8.13 or shall comply with Clauses 8.17.6.1 through 8.17.6.3.

#### 8.17.6.1 Through penetrations.

In occupancies other than Groups I-2 and I-3, a duct constructed of approved materials in accordance with the International Mechanical Code that penetrates a fire-resistance-rated floor/ceiling assembly that connects not more than two stories is permitted without shaft enclosure protection, provided that a listed fire damper is installed at the floor line or the duct is protected in accordance with Clause 8.14.5. For air transfer openings, see Clause 8.12.1.9.

**Exception:** A duct is permitted to penetrate three floors or less without a fire damper at each floor, provided that such duct meets all of the following requirements:

1. The duct shall be contained and located within the cavity of a wall and shall be constructed of steel having a minimum wall thickness of 0.4712 mm (0.0187 inches) (No. 26 gage).
2. The duct shall open into only one dwelling or sleeping unit and the duct system shall be continuous from the unit to the exterior of the building.
3. The duct shall not exceed 102 mm (4-inch) nominal diameter and the total area of such ducts shall not exceed 0.065 m² (100 square inches) in any 9.3 m² (100 square feet) of floor area.
4. The annular space around the duct is protected with materials that prevent the passage of flame and hot gases sufficient to ignite cotton waste where subjected to ASTM E119 time-temperature conditions under a minimum positive pressure differential of 2.49 Pa (0.01 inch) of water at the location of the penetration for the time period equivalent to the fire-resistance rating of the construction penetrated.

5. Grille openings located in a ceiling of a fire-resistance-rated floor/ceiling or roof/ceiling assembly shall be protected with a listed ceiling radiation damper installed in accordance with Clause 8.17.6.2.1.

#### 8.17.6.2 Membrane penetrations.

Ducts and air transfer openings constructed of approved materials in accordance with the International Mechanical Code that penetrate the ceiling membrane of a fire-resistance-rated floor/ceiling or roof/ceiling assembly shall be protected with one of the following:

1. A shaft enclosure in accordance with Clause 8.13.
2. A listed ceiling radiation damper installed at the ceiling line where a duct penetrates the ceiling of a fire-resistance-rated floor/ceiling or roof/ceiling assembly.

**Exceptions:**

1. A fire-resistance-rated assembly tested in accordance with ASTM E119 showing that ceiling radiation dampers are not required in order to maintain the fire-resistance rating of the assembly.
2. Where exhaust duct or outdoor air duct penetrations protected in accordance with Clause 8.14.5.2 are located within the cavity of a wall and do not pass through another dwelling unit or tenant space.
3. Where duct and air transfer openings are protected with a duct outlet penetration system tested as part of a fire-resistance-rated assembly in accordance with ASTM E119.
4. A listed ceiling radiation damper installed at the ceiling line where a diffuser with no duct attached penetrates the ceiling of a fire-resistance-rated floor/ceiling or roof/ceiling assembly.
Exceptions:

1. A fire-resistance-rated assembly tested in accordance with ASTM E119 showing that ceiling radiation dampers are not required in order to maintain the fire-resistance rating of the assembly.

2. Where duct and air transfer openings are protected with a duct outlet penetration system tested as part of a fire-resistance-rated assembly in accordance with ASTM E119.

8.17.6.2.1 Ceiling radiation dampers testing and installation.

Ceiling radiation dampers shall be tested in accordance with Clause 8.17.3.1. Ceiling radiation dampers shall be installed in accordance with the details listed in the fire-resistance-rated assembly and the manufacturer's instructions and the listing.

8.17.6.3 Nonfire-resistance-rated floor assemblies.

Duct systems constructed of approved materials in accordance with the International Mechanical Code that penetrate nonfire-resistance-rated floor assemblies shall be protected by any of the following methods:

1. A shaft enclosure in accordance with Clause 8.13.

2. The duct connects not more than two stories, and the annular space around the penetrating duct is protected with an approved noncombustible material that resists the free passage of flame and the products of combustion.

3. In floor assemblies composed of noncombustible materials, a shaft shall not be required where the duct connects not more than three stories, the annular space around the penetrating duct is protected with an approved noncombustible material that resists the free passage of flame and the products of combustion and a fire damper is installed at each floor line.

Exception: Fire dampers are not required in ducts within individual residential dwelling units.

8.17.7 Flexible ducts and air connectors.

Flexible ducts and air connectors shall not pass through any fire-resistance-rated assembly. Flexible air connectors shall not pass through any wall, floor or ceiling.

8.18 CONCEALED SPACES

8.18.1 General.

Fireblocking and draftstopping shall be installed in combustible concealed locations in accordance with this clause. Fireblocking shall comply with Clause 8.18.2. Draftstopping in floor/ceiling spaces and attic spaces shall comply with Clauses 8.18.3 and 8.18.4, respectively. The permitted use of combustible materials in concealed spaces of buildings of Type I or II construction shall be limited to the applications indicated in Clause 718.5.

8.18.2 Fireblocking.

In combustible construction, fireblocking shall be installed to cut off concealed draft openings (both vertical and horizontal) and shall form an effective barrier between floors, between a top storey and a roof or attic space. Fireblocking shall be installed in the locations specified in Clauses 8.18.2.2 through 8.18.2.7.

8.18.2.1 Fireblocking materials.

Fireblocking shall consist of the following materials:

1. Two-inch (51 mm) nominal timber.

2. Two thicknesses of 25 mm (1-inch) nominal timber with broken lap joints.

3. One thickness of 18.3 mm (0.719-inch) wood structural panels with joints backed by 18.3 mm (0.719-inch) wood structural panels.

4. One thickness of 19.1 mm (0.75-inch) particleboard with joints backed by 19 mm (0.75-inch) particleboard.

5. 12.7 mm (One-half-inch) gypsum board.
6. 6.4 mm (One-fourth-inch) cement-based millboard.

7. Batt or blankets of mineral wool, mineral fiber or other approved materials installed in such a manner as to be securely retained in place.

8. Cellulose insulation installed as tested for the specific application.

8.18.2.1 Batts or blankets of mineral wool or mineral fiber.

Batts or blankets of mineral wool or mineral fiber or other approved nonrigid materials shall be permitted for compliance with the 10-foot (3048 mm) horizontal fireblocking in walls constructed using parallel rows of studs or staggered studs.

8.18.2.1.2 Unfaced fiberglass.

Unfaced fiberglass batt insulation used as fireblocking shall fill the entire cross clause of the wall cavity to a minimum height of 406 mm (16 inches) measured vertically. Where piping, conduit or similar obstructions are encountered, the insulation shall be packed tightly around the obstruction.

8.18.2.1.3 Loose-fill insulation material.

Loose-fill insulation material, insulating foam sealants and caulk materials shall not be used as a fireblock unless specifically tested in the form and manner intended for use to demonstrate its ability to remain in place and to retard the spread of fire and hot gases.

8.18.2.1.4 Fireblocking integrity.

The integrity of fireblocks shall be maintained.

8.18.2.1.5 Double stud walls.

Batts or blankets of mineral or glass fiber or other approved nonrigid materials shall be allowed as fireblocking in walls constructed using parallel rows of studs or staggered studs.

8.18.2.2 Concealed wall spaces.

Fireblocking shall be provided in concealed spaces of stud walls and partitions, including furred spaces, and parallel rows of studs or staggered studs, as follows:

1. Vertically at the ceiling and floor levels.
2. Horizontally at intervals not exceeding 10 feet (3048 mm).

8.18.2.3 Connections between horizontal and vertical spaces.

Fireblocking shall be provided at interconnections between concealed vertical stud wall or partition spaces and concealed horizontal spaces created by an assembly of floor joists or trusses, and between concealed vertical and horizontal spaces such as occur at soffits, drop ceilings, cove ceilings and similar locations.

8.18.2.4 Stairways.

Fireblocking shall be provided in concealed spaces between stair stringers at the top and bottom of the run. Enclosed spaces under stairways shall comply with Clause 11.11.7.3.

8.18.2.5 Ceiling and floor openings.

Where required by Clause 8.12.1.8, Exception 1 of Clause 8.14.5.1.2 or Clause 8.14.6, fireblocking of the annular space around vents, pipes, ducts, chimneys and fireplaces at ceilings and floor levels shall be installed with a material specifically tested in the form and manner intended for use to demonstrate its ability to remain in place and resist the free passage of flame and the products of combustion.

8.18.2.5.1 Factory-built chimneys and fireplaces.

Factory-built chimneys and fireplaces shall be fireblocked in accordance with this Code.

8.18.2.6 Exterior wall coverings.

Fireblocking shall be installed within concealed spaces of exterior wall coverings and other exterior architectural elements where permitted to be of combustible construction as specified in this Code or where erected with combustible frames. Fireblocking shall be installed at maximum intervals of 6096 mm (20 feet) in either dimension so that there will be no
concealed space exceeding $9.3 \text{ m}^2$ (100 square feet) between fireblocking. Where wood furring strips are used, they shall be of approved wood of natural decay resistance or preservative-treated wood. If noncontinuous, such elements shall have closed ends, with not less than 102 mm (4 inches) of separation between clauses.

Exceptions:

1. Fireblocking of cornices is not required in single-family dwellings. Fireblocking of cornices of a two-family dwelling is required only at the line of dwelling unit separation.

2. Fireblocking shall not be required where the exterior wall covering is installed on noncombustible framing and the face of the exterior wall covering exposed to the concealed space is covered by one of the following materials:

   2.1. Aluminum having a minimum thickness of 0.5 mm (0.019 inch).

   2.2. Corrosion-resistant steel having a base metal thickness not less than 0.4 mm (0.016 inch) at any point.

   2.3. Other approved noncombustible materials.

3. Fireblocking shall not be required where the exterior wall covering has been tested in accordance with, and complies with the acceptance criteria of, the Ghana Fire Code. The exterior wall covering shall be installed as tested in accordance with the Ghana Fire Code.

8.18.2.7 Concealed sleeper spaces.

Where wood sleepers are used for laying wood flooring on masonry or concrete fire-resistance-rated floors, the space between the floor slab and the underside of the wood flooring shall be filled with an approved material to resist the free passage of flame and products of combustion or fireblocked in such a manner that open spaces under the flooring shall not exceed $9.3 \text{ m}^2$ (100 square feet) in area and such space shall be filled solidly under permanent partitions so that communication under the flooring between adjoining rooms shall not occur.

Exceptions:

1. Fireblocking is not required for slab-on-grade floors in gymnasiums.

2. Fireblocking is required only at the juncture of each alternate lane and at the ends of each lane in a bowling facility.

8.18.3 Draftstopping in floors.

Draftstopping shall be installed to subdivide floor/ceiling assemblies where required by Clause 8.8.4.2. In other than Group R occupancies, draftstopping shall be installed to subdivide combustible floor/ceiling assemblies so that horizontal floor areas do not exceed 93 m$^2$ (1,000 square feet).

Exception: Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

8.18.3.1 Draftstopping materials.

Draftstopping materials shall be not less than 12.7 mm (1/2-inch) gypsum board, 3/8-inch (9.5 mm) wood structural panel, 9.5 mm (3/8-inch) particleboard, 25-mm (1-inch) nominal timber, cement fiberboard, batts or blankets of mineral wool or glass fiber, or other approved materials adequately supported. The integrity of draftstops shall be maintained.

8.18.4 Draftstopping in attics.

Draftstopping shall be installed to subdivide attic spaces where required by Clause 8.8.4.2. In other than Group R, draftstopping shall be installed to subdivide combustible attic spaces and combustible concealed roof spaces such that any horizontal area does not exceed 279 m$^2$ (3,000 square feet). Ventilation of concealed roof spaces shall be maintained in accordance with this Code.

Exception: Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

8.18.4.1 Draftstopping materials.

Materials utilized for draftstopping of attic spaces shall comply with Clause 8.18.3.1.
8.18.4.1.1 Openings.

Openings in the partitions shall be protected by self-closing doors with automatic latches constructed as required for the partitions.

8.18.5 Combustible materials in concealed spaces in Type I or II construction.

Combustible materials shall not be permitted in concealed spaces of buildings of Type I or II construction.

Exceptions:

1. Combustible materials in accordance with Clause 7.33.
2. Combustible materials exposed within plenums complying with Clause 7.2 of the International Mechanical Code.
3. Class A interior finish materials classified in accordance with Clause 9.3.
4. Combustible piping within partitions or shaft enclosures installed in accordance with the provisions of this Code.
5. Combustible piping within concealed ceiling spaces installed in accordance with this Code.
6. Combustible insulation and covering on pipe and tubing, installed in concealed spaces other than plenums, complying with Clause 8.20.7.

8.19 FIRE-RESISTANCE REQUIREMENTS FOR PLASTER

8.19.1 Thickness of plaster.

The minimum thickness of gypsum plaster or Portland cement plaster used in a fire-resistance-rated system shall be determined by the prescribed fire tests. The plaster thickness shall be measured from the face of the lath where applied to gypsum lath or metal lath.

8.19.2 Plaster equivalents.

For fire-resistance purposes, 12.7 mm (1/2 inch) of unsanded gypsum plaster shall be deemed equivalent to 19.1 mm (3/4 inch) of 25 mm (one-to-three gypsum sand plaster or 1 inch) of Portland cement sand plaster.

8.19.3 Noncombustible furring.

In buildings of Type I and II construction, plaster shall be applied directly on concrete or masonry or on approved noncombustible plastering base and furring.

8.19.4 Double reinforcement.

Plaster protection more than 25 mm (1 inch) in thickness shall be reinforced with an additional layer of approved lath embedded not less than 19.1 mm (3/4 inch) from the outer surface and fixed securely in place.

Exception: Solid plaster partitions or where otherwise determined by fire tests.

8.19.5 Plaster alternatives for concrete.

In reinforced concrete construction, gypsum plaster or Portland cement plaster is permitted to be substituted for 12.7 mm (1/2 inch) of the required poured concrete protection, except that a minimum thickness of 3/8 inch (9.5 mm) of poured concrete shall be provided in reinforced concrete floors and 25 mm (1 inch) in reinforced concrete columns in addition to the plaster finish. The concrete base shall be prepared in accordance with Clause 26.10.7.

8.20 THERMAL- AND SOUND-INSULATING MATERIALS

8.20.1 General.

Insulating materials shall comply with the requirements of this clause. Where a flame spread index or a smoke-developed index is specified in this clause, such index shall be
determined in accordance with ASTM E84. Any material that is subject to an increase in flame spread index or smoke-developed index beyond the limits herein established through the effects of age, moisture or other atmospheric conditions shall not be permitted. Insulating materials, when tested in accordance with the requirements of this clause, shall include facings, when used, such as vapour retarders, vapour permeable membranes and similar coverings, and all layers of single and multilayer reflective foil insulation and similar materials.

Exceptions:

1. Fiberboard insulation shall comply with Part 24.
2. Foam plastic insulation shall comply with Part 27.
3. Duct and pipe insulation and duct and pipe coverings and linings in plenums shall comply with the International Mechanical Code.
4. All layers of single and multilayer reflective plastic core insulation shall comply with Clause 27.14.

8.20.2 Concealed installation.

Insulating materials, where concealed as installed in buildings of any type of construction, shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450. Exception: Cellulosic fiber loose-fill insulation complying with the requirements of Clause 8.20.6 shall not be required to meet a flame spread index requirement but shall be required to meet a smoke-developed index of not more than 450 when tested in accordance with this Code.

8.20.3 Exposed installation.

Insulating materials, where exposed as installed in buildings of any type of construction, shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450. Exception: Cellulosic fiber loose-fill insulation complying with the requirements of Clause 8.20.6 shall not be required to meet a flame spread index requirement but shall be required to meet a smoke-developed index of not more than 450 when tested in accordance with this Code.

8.20.4 Loose-fill insulation.

Loose-fill insulation materials that cannot be mounted in the ASTM E84 apparatus without a screen or artificial supports shall comply with the flame spread and smoke-developed limits of Clauses 8.20.2 and 8.20.3 when tested in accordance with this Code. Exception: Cellulosic fiber loose-fill insulation shall not be required to meet a flame spread index requirement when tested in accordance with this Code, provided that such insulation has a smoke-developed index of not more than 450 and complies with the requirements of Clause 8.20.6.

8.20.5 Roof insulation.

The use of combustible roof insulation not complying with Clauses 8.20.2 and 8.20.3 shall be permitted in any type of construction provided that insulation is covered with approved roof coverings directly applied thereto.

8.20.6 Cellulosic fiber loose-fill insulation and self-supported spray-applied cellulosic insulation.

Cellulosic fiber loose-fill insulation and self-supported spray-applied cellulosic insulation shall comply with this Code. Each package of
such insulating material shall be clearly labeled in accordance with this Code.

8.20.7 Insulation and covering on pipe and tubing.
Insulation and covering on pipe and tubing shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450.

Exception: Insulation and covering on pipe and tubing installed in plenums shall comply with this Code.

8.21 PRESCRIPTIVE FIRE RESISTANCE

8.21.1 General.
The provisions of this clause contain prescriptive details of fire-resistance-rated building elements, components or assemblies. The materials of construction listed in Tables 8.21.1(1), 8.21.1(2) and 8.21.1(3) shall be assumed to have the fire-resistance ratings prescribed therein. Where materials that change the capacity for heat dissipation are incorporated into a fire-resistance-rated assembly, fire test results or other substantiating data shall be made available to the building official to show that the required fire-resistance-rating time period is not reduced.
### TABLE 8.21.1(1)

**MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS**

<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR THE FOLLOWING FIRE-RESISTANCE PERIODS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>1-1.1 Carbonate, lightweight and sand-lightweight aggregate concrete, members 6&quot; × 6&quot; or greater (not including sandstone, granite and siliceous gravel). *</td>
<td>1-1.1</td>
<td>2</td>
<td>1 1/2</td>
</tr>
<tr>
<td>1-1.2 Carbonate, lightweight and sand-lightweight aggregate concrete, members 8&quot; × 8&quot; or greater (not including sandstone, granite and siliceous gravel).*</td>
<td>1-1.2</td>
<td>2</td>
<td>1 1/2</td>
</tr>
<tr>
<td>1-1.3 Carbonate, lightweight and sand-lightweight aggregate concrete, members 12&quot; × 12&quot; or greater (not including sandstone, granite and siliceous gravel).*</td>
<td>1-1.3</td>
<td>1 1/2</td>
<td>1</td>
</tr>
<tr>
<td>1-1.4 Siliceous aggregate concrete and concrete excluded in Item 1-1.1, members 6&quot; × 6&quot; or greater.*</td>
<td>1-1.4</td>
<td>2</td>
<td>1 1/2</td>
</tr>
<tr>
<td>1-1.5 Siliceous aggregate concrete and concrete excluded in Item 1-1.1, members 8&quot; × 8&quot; or greater.*</td>
<td>1-1.5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1-1.6 Siliceous aggregate concrete and concrete excluded in Item 1-1.1, members 12&quot; × 12&quot; or greater.*</td>
<td>1-1.6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1-2.1 Clay or shale brick with brick and mortar fill.*</td>
<td>1-2.1</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>1-3.1 4&quot; hollow clay tile in two 2&quot; layers; 1/2&quot; mortar between tile and column; 1/4&quot; metal mesh 0.046&quot; wire diameter in horizontal joints; tile fill.*</td>
<td>1-3.1</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>1-3.2 2&quot; hollow clay tile; 1/4&quot; mortar between tile and column; 1/4&quot; metal mesh 0.046&quot; wire diameter in horizontal joints; limestone or trap-rock concrete fill; plastered with 1/4&quot; gypsum plaster.</td>
<td>1-3.2</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>1-3.3 2&quot; hollow clay tile with outside wire ties 0.08&quot; diameter at each course of tile or 1/4&quot; metal mesh 0.046&quot; diameter wire in horizontal joints; limestone or trap-rock concrete fill extending 1&quot; outside column on all sides.</td>
<td>1-3.3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-3.4 2&quot; hollow clay tile with outside wire ties 0.08&quot; diameter at each course of tile without concrete fill; 1/4&quot; mortar between tile and column.</td>
<td>1-3.4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-4.1 Cement plaster over metal lath wire tied to 1/2&quot; cold-rolled vertical channels with 0.049&quot; (No. 18 B.W. gage) wire tied spaced 3&quot; to 6&quot; on center. Plaster mixed 1:2 by volume, cement to sand.</td>
<td>1-4.1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-5.1 Vermiculite concrete, 1:4 mix by volume over paper-backed wire fabric lath wrapped directly around column with additional 2&quot; × 2&quot; 0.065&quot;/0.065&quot; (No. 16/16 B.W. gage) wire fabric placed 1/2&quot; from outer concrete surface. Wire fabric tied with 0.049&quot; (No. 18 B.W. gage) wire spaced 6&quot; on center for inner layer and 2&quot; on center for outer layer.</td>
<td>1-5.1</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>1-6.1 Perlite or vermiculite gypsum plaster over metal lath wrapped around column and faced 1 1/2&quot; from column flanges. Sheets lapped at ends and tied at 6&quot; intervals with 0.049&quot; (No. 18 B.W. gage) tie wire. Plaster pushed through to flanges.</td>
<td>1-6.1</td>
<td>1 1/2</td>
<td>1</td>
</tr>
<tr>
<td>1-6.2 Perlite or vermiculite gypsum plaster over self-furring metal lath wrapped directly around column, lapped 1&quot; and tied at 6&quot; intervals with 0.049&quot; (No. 18 B.W. gage) wire.</td>
<td>1-6.2</td>
<td>1 1/2</td>
<td>1</td>
</tr>
<tr>
<td>1-6.3 Perlite or vermiculite gypsum plaster on metal lath applied to 1/2&quot; cold-rolled channels spaced 24&quot; apart vertically and wrapped flatwise around column.</td>
<td>1-6.3</td>
<td>1/2</td>
<td>—</td>
</tr>
<tr>
<td>1-6.4 Perlite or vermiculite gypsum plaster over two layers of 1/4&quot; plain full-length gypsum lath applied tight to column flanges. Lath wrapped with 1&quot; hexagonal mesh of No. 20 gage wire and tied with doubled 0.035&quot; diameter (No. 18 B.W. gage) wire ties spaced 23&quot; on center. For three-coat work, the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2 1/2 cubic feet of aggregate for the 3-hour system.</td>
<td>1-6.4</td>
<td>2</td>
<td>—</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 8.21.1(1)—continued

**MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS**

<table>
<thead>
<tr>
<th>Structural Parts to be Protected</th>
<th>Item Number</th>
<th>Insulating Material Used</th>
<th>Minimum Insulation Thickness for the Following Fire-Resistance Periods (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td><strong>1. Steel columns and all of primary trusses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-6.5</td>
<td>Perlite or vermiculite gypsum plaster over one layer of ( \frac{1}{2} )-inch plain full-length gypsum lath applied tight to column flanges. Lath tied with doubled 0.049&quot; (No. 18 B.W. gage) wire ties spaced 23&quot; on center and scratch coat wrapped with 1&quot; hexagonal mesh 0.035&quot; (No. 20 B.W. gage) wire fabric. For three-coat work, the plaster mix for the second coat shall not exceed 100 pounds of gypsum to 2( \frac{1}{4} ) cubic feet of aggregate.</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>1-7.1</td>
<td>Multiple layers of ( \frac{1}{2} )-inch gypsum wallboard adhesively secured to column flanges and successive layers. Wallboard applied without horizontal joints. Corner edges of each layer staggered. Wallboard layer below outer layer secured to column with doubled 0.049&quot; (No. 18 B.W. gage) steel wire ties spaced 15&quot; on center. Exposed corners taped and treated.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-7.2</td>
<td>Three layers of ( \frac{1}{4} )-inch Type X gypsum wallboard. First and second layer held in place by ( \frac{1}{4} )-inch diameter by ( \frac{1}{2} )-inch long ring shank nails with ( \frac{1}{4} )-inch diameter heads spaced 24&quot; on center at corners. Middle layer also secured with metal straps at mid-height and 18&quot; from each end, and by metal corner bead at each corner held by the metal straps. Third layer attached to corner bead with 1&quot; long gypsum wallboard screws spaced 12&quot; on center.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-7.3</td>
<td>Three layers of ( \frac{1}{4} )-inch Type X gypsum wallboard; each layer screw attached to ( \frac{1}{4} )-inch steel studs 0.018&quot; thick (No. 25 carbon sheet steel gage) at each corner of column. Middle layer also secured with 0.049&quot; (No. 18 B.W. gage) double-strand steel wire ties, 24&quot; on center. Screws are No. 6 by 1&quot; spaced 24&quot; on center for inner layer, No. 6 by ( V_4 )&quot; spaced 12&quot; on center for middle layer and No. 8 by 2( \frac{1}{4} )&quot; spaced 12&quot; on center for outer layer.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-8.1</td>
<td>Wood-fibered gypsum plaster mixed 1:1 by weight gypsum-to-sand aggregate applied over metal lath. Lath lapped 1&quot; and tied 6&quot; on center at all end, edges and spacers with 0.049&quot; (No. 18 B.W. gage) steel tie wires. Plaster applied over ( \frac{1}{4} )-inch spacers made of ( \frac{1}{4} )-inch, furring channel with 2&quot; legs located around each corner. Spacers located 1&quot; from top and bottom of member and not greater than 40&quot; on center and wire tied with a single strand of 0.049&quot; (No. 18 B.W. gage) steel tie wires. Corner bead tied to the lath at 6&quot; on center along each corner to provide plaster thickness.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1-9.1</td>
<td>Minimum 8x35 wide flange steel column (w/d ( \geq ) 0.75) with each web cavity filled even with the flange tip with normal weight carbonate or siliceous aggregate concrete (3,000 psi minimum compressive strength with 145 pcf \pm 5 pcf unit weight). Reinforce the concrete in each web cavity with a minimum No. 4 deformed reinforcing bar installed vertically and centered in the cavity, and secured to the column web with a minimum No. 2 horizontal deformed reinforcing bar welded to the web every 18&quot; on center vertically. As an alternative to the No. 4 rebars, ( \frac{1}{4} )-inch diameter by 3&quot; long headed studs, spaced at 12&quot; on center vertically, shall be welded on each side of the web midway between the column flanges.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. Webs or flanges of steel beams and girders (continued)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1.1</td>
<td>Carbonate, lightweight and sand lightweight aggregate concrete (not including sandstone, granite and siliceous gravel) with 5&quot; or finer metal mesh placed 1&quot; from the finished surface anchored to the top flange and providing not less than 0.025 square inch of steel area per foot in each direction.</td>
<td>2</td>
<td>( V_2 )</td>
</tr>
<tr>
<td>2-1.2</td>
<td>Siliceous aggregate concrete and concrete excluded in Item 2-1.1 with 3&quot; or finer metal mesh placed 1&quot; from the finished surface anchored to the top flange and providing not less than 0.025 square inch of steel area per foot in each direction.</td>
<td>2( \frac{1}{2} )</td>
<td>2</td>
</tr>
<tr>
<td>2-2.1</td>
<td>Cement plaster on metal lath attached to ( \frac{1}{2} )-inch cold-rolled channels with 0.049&quot; (No. 18 B.W. gage) wire ties spaced 3&quot; to 6&quot; on center. Plaster mixed 1:2 ( \frac{1}{2} ) by volume, cement to sand.</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 8.21.1(1)—continued

**MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS**

<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR THE FOLLOWING FIRE-RESISTANCE PERIODS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>2-3.1</td>
<td>Vermiculite gypsum plaster on a metal lath cage, wire tied to 0.165&quot; diameter (No. 8 B.W. gage) steel wire hangers wrapped around beam and spaced 16&quot; on center. Metal lath ties spaced approximately 5&quot; on center at cage sides and bottom.</td>
<td>—</td>
<td>7/8</td>
</tr>
<tr>
<td>2-4.1</td>
<td>Two layers of 1/4&quot; X 2&quot; gypsum wallboard are attached to U-shaped brackets spaced 24&quot; on center. 0.018&quot; thick (No. 25 carbon sheet steel gage) 1/4&quot; deep by 1&quot; galvanized steel runner channels are first installed parallel to and on each side of the top beam flange to provide a 1/2&quot; clearance to the flange. The channel runners are attached to steel deck or concrete floor construction with approved fasteners spaced 12&quot; on center. U-shaped brackets are formed from members identical to the channel runners. At the bent portion of the U-shaped bracket, the flanges of the channel are cut out so that 1/4&quot; deep corner channels can be inserted without attachment parallel to each side of the lower flange. As an alternative, 0.021&quot; thick (No. 34 carbon sheet steel gage) 1&quot; x 2&quot; runner and corner angles shall be used in lieu of channels, and the web cutouts in the U-shaped brackets shall not be required. Each angle is attached to the bracket with 1/4&quot;-long No. 8 self-drilling screws. The vertical legs of the U-shaped bracket are attached to the runners with one 1/4&quot;-long No. 8 self-drilling screw. The completed steel framing provides a 2 1/4&quot; and 1&quot; space between the inner layer of wallboard and the sides and bottom of the steel beam, respectively. The inner layer of wallboard is attached to the top runners and bottom corner channels or corner angles with 1 1/4&quot;-long No. 6 self-drilling screws spaced 16&quot; on center. The outer layer of wallboard is applied with 1 1/4&quot;-long No. 6 self-drilling screws spaced 8&quot; on center. The bottom corners are reinforced with metal corner beads.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2-4.2</td>
<td>Three layers of 1/8&quot; X 2&quot; gypsum wallboard are attached to a steel suspension system as described immediately above utilizing the 0.018&quot; thick (No. 25 carbon sheet steel gage) 1&quot; x 2&quot; lower corner angles. The framing is located so that a 2 1/4&quot; and 2&quot; space is provided between the inner layer of wallboard and the sides and bottom of the beam, respectively. The first two layers of wallboard are attached as described immediately above. A layer of 0.035&quot; thick (No. 20 B.W. gage) 1&quot; hexagonal galvanized wire mesh is applied under the soffit of the middle layer and up the sides approximately 2&quot;. The mesh is held in position with the No. 6 1 1/4&quot;-long screws installed in the vertical leg of the bottom corner angles. The outer layer of wallboard is attached with No. 6 2 1/4&quot;-long screws spaced 8&quot; on center. One screw is installed at the mid-depth of the bracket in each layer. Bottom corners are finished as described above.</td>
<td>—</td>
<td>1 1/4</td>
</tr>
<tr>
<td>3.1.1</td>
<td>Carbonate, lightweight, sand-lightweight and siliceous aggregate concrete Beams or girders</td>
<td>4&quot;</td>
<td>3&quot;</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 8.21.1(1)—continued

**MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS**

**FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS**

<table>
<thead>
<tr>
<th>STRUCTURAL PARTS TO BE PROTECTED</th>
<th>ITEM NUMBER</th>
<th>INSULATING MATERIAL USED</th>
<th>MINIMUM THICKNESS OF INSULATING MATERIAL FOR THE FOLLOWING FIRE-RESISTANCE PERIODS (inches)</th>
</tr>
</thead>
</table>
| 4. Bonded or unbonded post-tensioned tendons in prestressed concrete | 4-1.1      | Carbonate, lightweight, sand-lightweight and siliceous aggregate concrete Unrestrained members:  
Solid slabs<sup>b</sup>  
Beams and girders<sup>c</sup>  
8" wide  
greater than 12" wide | | |
| | | | 4 hours | 3 hours | 2 hours | 1 hour |
| | | | — | 2 | 1<sup>1/4</sup> | — |
| | | | 3 | 2<sup>1/2</sup> | 2 | 1<sup>1/4</sup> |
| 4.1.2 | Carbonate, lightweight, sand-lightweight and siliceous aggregate Restrainted members<sup>a</sup>  
Solid slabs<sup>b</sup>  
Beams and girders<sup>c</sup>  
8" wide  
greater than 12" wide | | | | | | |
| | | | 1<sup>1/4</sup> | 1 | 1<sup>1/4</sup> | — |
| | | | 2<sup>1/2</sup> | 2 | 1<sup>1/4</sup> | — |
| | | | 2 | 1<sup>1/4</sup> | 1<sup>1/2</sup> | — |
| 5. Reinforcing steel in reinforced concrete columns, beams, girders and trusses | 5-1.1      | Carbonate, lightweight and sand-lightweight aggregate concrete, members 12" or larger, square or round. (Size limit does not apply to beams and girders monolithic with floors.)  
Siliceous aggregate concrete, members 12" or larger, square or round. (Size limit does not apply to beams and girders monolithic with floors.) | | |
| | | | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1<sup>1/4</sup> |
| | | | 2 | 1<sup>1/2</sup> | 1<sup>1/2</sup> | 1<sup>1/2</sup> |
| 6. Reinforcing steel in reinforced concrete joists<sup>d</sup> | 6-1.1      | Carbonate, lightweight and sand-lightweight aggregate concrete  
Siliceous aggregate concrete | | |
| | | | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1 | 1<sup>1/4</sup> |
| | | | 2 | 1<sup>1/2</sup> | 1<sup>1/2</sup> | 1<sup>1/2</sup> |
| | 6-1.2 | Carbonate, lightweight and sand-lightweight aggregate concrete  
Siliceous aggregate concrete | | | | |
| | | | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1 | 1<sup>1/4</sup> |
| | | | 2 | 1<sup>1/2</sup> | 1<sup>1/2</sup> | 1<sup>1/2</sup> |
| 7. Reinforcing and tie rods in floor and roof slabs<sup>d</sup> | 7-1.1      | Carbonate, lightweight and sand-lightweight aggregate concrete  
Siliceous aggregate concrete | | |
| | | | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1<sup>1/4</sup> |
| | | | 2 | 1<sup>1/2</sup> | 1<sup>1/2</sup> | 1<sup>1/2</sup> |
| | 7-1.2 | Carbonate, lightweight and sand-lightweight aggregate concrete  
Siliceous aggregate concrete | | | | |
| | | | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1<sup>1/4</sup> | 1<sup>1/4</sup> |
| | | | 2 | 1<sup>1/2</sup> | 1<sup>1/2</sup> | 1<sup>1/2</sup> |

**Note:** For SI: 1 inch = 25.4 mm, 1 square inch = 645.2 mm, 1 cubic foot = 0.0283 m, 1 pound per cubic foot = 16.02 kg/m³.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Reentrant parts of protected members to be filled solidly.</td>
</tr>
<tr>
<td>b.</td>
<td>Two layers of equal thickness with a 1/4-inch airspace between.</td>
</tr>
<tr>
<td>c.</td>
<td>For all of the construction with gypsum wallboard described in this Code, gypsum base for veneer plaster of the same size, thickness and core type shall be permitted to be substituted for gypsum wallboard, provided that attachment is identical to that specified for the wallboard and the joints on the face layer are reinforced, and the entire surface is covered with not less than 1/16-inch gypsum veneer plaster.</td>
</tr>
<tr>
<td>d.</td>
<td>An approved adhesive qualified under ASTM E119.</td>
</tr>
<tr>
<td>e.</td>
<td>Where lightweight or sand-lightweight concrete having an oven-dry weight of 110 pounds per cubic foot or less is used, the tabulated minimum cover shall be permitted to be reduced 25 percent, except that the reduced cover shall not be less than 1/3 inch in slabs or 1/4 inches in beams or girders.</td>
</tr>
<tr>
<td>f.</td>
<td>For solid slabs of siliceous aggregate concrete, increase tendon cover 20 percent.</td>
</tr>
<tr>
<td>g.</td>
<td>Adequate provisions against spalling shall be provided by U-shaped or hooped stirrups spaced not to exceed the depth of the member with a clear cover of 1 inch.</td>
</tr>
<tr>
<td>h.</td>
<td>Prestressed slabs shall have a thickness not less than that required in this Code for the respective fire-resistance time period.</td>
</tr>
<tr>
<td>i.</td>
<td>Fire coverage and end anchorages shall be as follows: Cover to the prestressing steel at the anchor shall be 1 inch greater than that required away from the anchor. Minimum cover to steel-bearing plate shall be 1 inch in beams and 3/4 inch in slabs.</td>
</tr>
<tr>
<td>j.</td>
<td>For beam widths between 8 inches and 12 inches, cover thickness shall be permitted to be determined by interpolation.</td>
</tr>
<tr>
<td>k.</td>
<td>Interior spans of continuous slabs, beams and girders shall be permitted to be considered restrained.</td>
</tr>
<tr>
<td>l.</td>
<td>For use with concrete slabs having a comparable fire endurance where members are framed into the structure in such a manner as to provide equivalent performance to that of monolithic concrete construction.</td>
</tr>
<tr>
<td>m.</td>
<td>Generic fire-resistance ratings (those not designated as PROPRIETARY* in the listing) in GA 600 shall be accepted as if herein listed.</td>
</tr>
</tbody>
</table>
Additional insulating material is not required on the exposed outside face of the column flange to achieve a 1-hour fire-resistance rating.

### TABLE 8.21.1(2)

**RATED FIRE-RESISTANCE PERIODS FOR VARIOUS WALLS AND PARTITIONS a, o, p**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE&quot; (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>1. Brick of clay or shale</td>
<td>1-1.1</td>
<td>Solid brick of clay or shale.</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1-1.2</td>
<td>Hollow brick, not filled.</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>1-1.3</td>
<td>Hollow brick unit wall, grout or filled with perlite vermiculite or expanded shale aggregate.</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>1-2.1</td>
<td>4&quot; nominal thick units not less than 75 percent solid backed with a hat-shaped metal furring channel 1/8&quot; thick formed from 0.021&quot; sheet metal attached to the brick wall on 24&quot; centers with approved fasteners, and 1/2&quot; Type X gypsum wallboard attached to the metal furring strips with 1&quot; long Type S screws spaced 8&quot; on center.</td>
<td>—</td>
</tr>
<tr>
<td>2. Combination of clay brick and load-bearing hollow clay tile</td>
<td>2-1.1</td>
<td>4&quot; solid brick and 4&quot; tile (not less than 40 percent solid).</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>2-1.2</td>
<td>4&quot; solid brick and 8&quot; tile (not less than 40 percent solid).</td>
<td>12</td>
</tr>
<tr>
<td>3. Concrete masonry units</td>
<td>3-1.1</td>
<td>Expanded slag or pumice.</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>3-1.2</td>
<td>Expanded clay, shale or slate.</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>3-1.3</td>
<td>Limestone, cinders or air-cooled slag.</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>3-1.4</td>
<td>Calcereous or siliceous gravel.</td>
<td>6.2</td>
</tr>
<tr>
<td>4. Solid concrete</td>
<td>4.1.1</td>
<td>Siliceous aggregate concrete.</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbonate aggregate concrete.</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sand-lightweight concrete.</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lightweight concrete.</td>
<td>5.1</td>
</tr>
<tr>
<td>5. Glazed or unglazed facing tile, nonload-bearing</td>
<td>5-1.1</td>
<td>One 2&quot; unit cored 15 percent maximum and one 4&quot; unit cored 25 percent maximum with 1/2&quot; mortar-filled collar joint. Unit positions reversed in alternate courses.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.2</td>
<td>One 2&quot; unit cored 15 percent maximum and one 4&quot; unit cored 40 percent maximum with 1/2&quot; mortar-filled collar joint. Unit positions side with 1/2&quot; gypsum plaster. Two wythes tied together every fourth course with No. 22 gage corrugated metal ties.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.3</td>
<td>One unit with three cells in wall thickness, cored 29 percent maximum.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.4</td>
<td>One 2&quot; unit cored 22 percent maximum and one 4&quot; unit cored 41 percent maximum with 1/2&quot; mortar-filled collar joint. Two wythes tied together every third course with 0.030&quot; (No. 22 galvanized sheet steel gage) corrugated metal ties.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.5</td>
<td>One 4&quot; unit cored 25 percent maximum with 1/2&quot; gypsum plaster on one side.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.6</td>
<td>One 4&quot; unit with two cells in wall thickness, cored 22 percent maximum.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.7</td>
<td>One 4&quot; unit cored 30 percent maximum with 1/2&quot; vermiculite gypsum plaster on one side.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>5-1.8</td>
<td>One 4&quot; unit cored 39 percent maximum with 1/2&quot; gypsum plaster on one side.</td>
<td>—</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 8.21.1(2)—continued

**RATED FIRE-RESISTANCE PERIODS FOR VARIOUS WALLS AND PARTITIONS a, o, p**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>6. Solid gypsum plaster</td>
<td>6-1.1</td>
<td>$1/4&quot;$ by $0.055&quot;$ (No. 16 carbon sheet steel gage) vertical cold-rolled channels, $16&quot;$ on center with 2.6-pound flat metal lath applied to one face and tied with $0.049&quot;$ (No. 18 B.W. gage) wire at $6&quot;$ spacing. Gypsum plaster each side mixed $1:2$ by weight, gypsum to sand aggregate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-1.2</td>
<td>$1/4&quot;$ by $0.055&quot;$ (No. 16 carbon sheet steel gage) cold-rolled channels $16&quot;$ on center with metal lath applied to one face and tied with $0.049&quot;$ (No. 18 B.W. gage) wire at $6&quot;$ spacing. Perlite or vermiculite gypsum plaster each side. For three-coat work, the plaster mix for the second coat shall not exceed 100 pounds of gypsum to $2^{1/2}_{1}$ cubic feet of aggregate for the 1-hour system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-1.3</td>
<td>$1/4&quot;$ by $0.055&quot;$ (No. 16 carbon sheet steel gage) vertical cold-rolled channels, $16&quot;$ on center with $1/2&quot;$ gypsum lath applied to one face and attached with sheet metal clips. Gypsum plaster each side mixed $1:2$ by weight, gypsum to sand aggregate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-2.1</td>
<td>Studiess with $1/4&quot;$ full-length plain gypsum lath and gypsum plaster each side. Plaster mixed $1:1$ for scratch coat and $1:2$ for brown coat, by weight, gypsum to sand aggregate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-2.2</td>
<td>Studiess with $1/4&quot;$ full-length plain gypsum lath and perlite or vermiculite gypsum plaster each side.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-2.3</td>
<td>Studiess partition with $1/4&quot;$ nth metal lath installed vertically adjacent edges tied $6&quot;$ on center with No. 18 gage wire ties, gypsum plaster each side mixed $1:2$ by weight, gypsum to sand aggregate.</td>
<td></td>
</tr>
<tr>
<td>7. Solid perlite and Portland cement</td>
<td>7-1.1</td>
<td>Perlite mixed in the ratio of $3$ cubic feet to $100$ pounds of Portland cement and machine applied to stud side of $1/2&quot;$ mesh by $0.055$-inch (No. 17 B.W. gage) paper-backed woven wire fabric lath wire-tied to $4&quot;$ deep steel trussed wire $1$ stud $16&quot;$ on center. Wire ties of $0.049&quot;$ (No. 18 B.W. gage) galvanized steel wire $6&quot;$ on center vertically.</td>
<td></td>
</tr>
<tr>
<td>8. Solid neat wood fibered gypsum plaster</td>
<td>8-1.1</td>
<td>$1/4&quot;$ by $0.055$-inch (No. 16 carbon sheet steel gage) cold-rolled channels, $12&quot;$ on center with $2.5$-pound flat metal lath applied to one face and tied with $0.049&quot;$ (No. 18 B.W. gage) wire at $6&quot;$ spacing. Neat gypsum plaster applied each side.</td>
<td></td>
</tr>
<tr>
<td>9. Solid wallboard partition</td>
<td>9-1.1</td>
<td>One full-length layer $1/2&quot;$ Type X gypsum wallboard laminated to each side of $1&quot;$ full-length V-edge gypsum coreboard with approved laminating compound. Vertical joints of face layer and coreboard staggered not less than $3&quot;$.</td>
<td></td>
</tr>
<tr>
<td>10. Hollow (studless) gypsum wallboard partition</td>
<td>10-1.1</td>
<td>One full-length layer of $1/2&quot;$ Type X gypsum wallboard laminated to both sides of wood or metal top and bottom runners laminated to each side of $1&quot;$ fast $6&quot;$ full-length gypsum coreboard ribs spaced $2&quot;$ on center with approved laminating compound. Ribs centered at vertical joints of face plies and joints staggered $24&quot;$ in opposing faces. Ribs may be recessed $6&quot;$ from the top and bottom.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10-1.2</td>
<td>$1&quot;$ regular gypsum V-edge full-length backing board attached to both sides of wood or metal top and bottom runners with nails or $1/2&quot;$ drywall screws at $24&quot;$ on center. Minimum width of runners $1/2&quot;$. Face layer of $1/2&quot;$ regular full-length gypsum wallboard laminated to outer faces of backing board with approved laminating compound.</td>
<td></td>
</tr>
</tbody>
</table>

(Continued)
<table>
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<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>11. Noncombustible studs-interior partition with plaster each side</td>
<td>11-1.1</td>
<td>$3/8'' \times 0.044''$ (No. 18 carbon steel gage) steel studs spaced 24'' on center. $5/8''$ gypsum plaster on metal lath each side mixed 1:2 by weight, gypsum to sand aggregate.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>11-1.2</td>
<td>$3/4'' \times 0.055''$ (No. 16 carbon steel gage) approved nailable steel studs spaced 24'' on center. $5/8''$ sheet steel fibered plaster each side over $5/8''$ rib metal lath nailed to studs with 6d common nails, $8''$ on center. Nails driven $1\frac{1}{4}''$ and bent over.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>11-1.3</td>
<td>$4'' \times 0.044''$ (No. 18 carbon steel gage) channel-shaped steel studs at 16'' on center. On each side approved resilient clips pressed onto stud flange at 16'' vertical spacing. $1\frac{1}{4}''$ pencil rods snapped into or wire tied onto outer loop of clips, metal lath wire-tied to pencil rods at 6'' intervals, $1''$ perlite gypsum plaster, each side.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>11-1.4</td>
<td>$2\frac{1}{2}'' \times 0.044''$ (No. 18 carbon steel gage) steel studs spaced 16'' on center. Wood fibered gypsum plaster mixed 1:1 by weight gypsum to sand aggregate applied over $1/4''$-pound metal lath wire-tied to studs, each side. $5/8''$ plaster applied over each face, including finish coat.</td>
<td>—</td>
</tr>
<tr>
<td>12. Wood studs-interior partition with plaster each side</td>
<td>12-1.1a</td>
<td>$2'' \times 4''$ wood studs 16'' on center with $5/8''$ gypsum plaster on metal lath. Lath attached by 4d common nails bent over or No. 14 gage by $1\frac{1}{4}''$ by $1\frac{1}{4}''$ crown width staples spaced 6'' on center. Plaster mixed 1:1$1/2$ for scratch coat and 1:3 for brown coat, by weight, gypsum to sand aggregate.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>12-1.2a</td>
<td>$2'' \times 4''$ wood studs 16'' on center with metal lath and $5/8''$ neat wood-fibered gypsum plaster each side. Lath attached by 6d common nails, $7''$ on center. Nails driven $1\frac{1}{4}''$ and bent over.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>12-1.3a</td>
<td>$2'' \times 4''$ wood studs 16'' on center with $5/8''$ perforated or plain gypsum lath and $1\frac{1}{2}''$ gypsum plaster each side. Lath nailed with $1\frac{1}{4}''$ by No. 13 gage by $1\frac{1}{4}''$ head plasterboard blue nails, $4''$ on center. Plaster mixed 1:2 by weight, gypsum to sand aggregate.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>12-1.4a</td>
<td>$2'' \times 4''$ wood studs 16'' on center with $5/8''$ Type X gypsum lath and $1\frac{1}{4}''$ gypsum plaster each side. Lath nailed with $1\frac{1}{4}''$ by No. 13 gage by $1\frac{1}{4}''$ head plasterboard blue nails, $5''$ on center. Plaster mixed 1:2 by weight, gypsum to sand aggregate.</td>
<td>—</td>
</tr>
<tr>
<td>13. Noncombustible studs-interior partition with gypsum wallboard each side</td>
<td>13-1.1</td>
<td>$0.018''$ (No. 25 carbon steel gage) channel-shaped studs 24'' on center with one &quot;full-length layer of $5/8''$ Type X gypsum wallboard&quot; applied vertically attached with 1'-long No. 6 drywall screws to each stud. Screws are $8''$ on center around the perimeter and $12''$ on center on the intermediate stud. Where applied horizontally, the Type X gypsum wallboard shall be attached to $3\frac{1}{8}''$ studs and the horizontal joints shall be staggered with those on the opposite side. Screws for the horizontal application shall be $8''$ on center at vertical edges and $12''$ on center at intermediate studs.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>13-1.2</td>
<td>$0.018''$ (No. 25 carbon steel gage) channel-shaped studs 25'' on center with two &quot;full-length layers of $5/8''$ Type X gypsum wallboard&quot; applied vertically each side. First layer attached with 1'-long, No. 6 drywall screws, $8''$ on center around the perimeter and 12'' on center on the intermediate stud. Second layer attached with vertical joints offset one stud space from first layer using $1\frac{3}{4}''$ long, No. 6 drywall screws spaced 9'' on center along vertical joints, 12'' on center at intermediate studs and 24'' on center along top and bottom runners.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>13-1.3</td>
<td>$0.055''$ (No. 16 carbon steel gage) approved nailable metal studs $24''$ on center with full-length $5/8''$ Type X gypsum wallboard&quot;applied vertically and nailed 7'' on center with 6d common-coated common nails. Approved metal fastener grips used with nails at vertical butt joints along studs.</td>
<td>—</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 8.21.1(2)—continued

**RATED FIRE-RESISTANCE PERIODS FOR VARIOUS WALLS AND PARTITIONS** a, o, p

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
</tr>
<tr>
<td>14-1.1.n</td>
<td>2&quot; × 4&quot; wood studs 16&quot; on center with two layers of 1/2&quot; regular gypsum wallboard each side, 4d common or wallboard nails at 8&quot; on center first layer, 5d common or wallboard nails at 8&quot; on center second layer with laminating compound between layers, joints staggered. First layer applied full length vertically, second layer applied horizontally or vertically.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14-1.2.a</td>
<td>2&quot; × 4&quot; wood studs 16&quot; on center with two layers 1/4&quot; regular gypsum wallboard applied vertically or horizontally each side, joints staggered. Nail base layer with 5d common or wallboard nails at 8&quot; on center face layer with 8d common or wallboard nails at 8&quot; on center.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14-1.3.a</td>
<td>2&quot; × 4&quot; wood studs 24&quot; on center with 1/2&quot; Type X gypsum wallboard applied vertically or horizontally nailed with 6d common or wallboard nails at 7&quot; on center with end joints on nailing members. Stagger joints each side.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14-1.4.a</td>
<td>2&quot; × 4&quot; fire-retardant-treated wood studs spaced 24&quot; on center with one layer of 1/2&quot; Type X gypsum wallboard applied with face paper grain (long dimension) parallel to studs. Wallboard attached with 6d common or wallboard nails at 7&quot; on center.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14-1.5.a</td>
<td>2&quot; × 4&quot; wood studs 16&quot; on center with two layers 1/2&quot; Type X gypsum wallboard applied vertically and nailed with 6d common or wallboard nails at 9½&quot; on center. Face layer applied vertically or horizontally and nailed with 8d common or wallboard nails at 7&quot; on center. For nail-adhesive application, base layers are nailed 6&quot; on center. Face layers applied with coating of approved wallboard adhesive and nailed 12½&quot; on center.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>14-1.6.a</td>
<td>2&quot; × 3½&quot; fire-retardant-treated wood studs spaced 24&quot; on center with one layer of 1/2&quot; Type X gypsum wallboard applied with face paper grain (long dimension) at right angles to studs. Wallboard attached with 6d cement-coated nails spaced 7&quot; on center.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15-1.1.a</td>
<td>Exterior surface with 1/4&quot; drop siding over 1/2&quot; gypsum sheathing on 2×4 wood studs at 16&quot; on center. Interior surface treatment as required for 1-hour-rated exterior or interior 2×4 wood stud partitions. Gypsum sheathing nailed with 1½&quot;) by No. 11 gage by 1½&quot;) head galvanized nails spaced 8&quot; on center. Siding nailed with 7d galvanized smooth box nails.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15-1.2.a</td>
<td>2×4 wood studs 16&quot; on center with metal lath and 1/2&quot; cement plaster on each side. Lath attached with 6d common nails 7&quot; on center driven to 1&quot; minimum penetration and bent over. Plaster mix 1:3 for scratch coat and 1:5 for brown coat, by volume, cement to sand.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15-1.3.a</td>
<td>2×4 wood studs 16&quot; on center with 1/4&quot; cement plaster (measured from the face of studs) on the exterior surface with interior surface treatment as required for interior wood stud partitions in this table. Plaster mix 1:3 for scratch coat and 1:5 for brown coat, by volume, cement to sand.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15-1.4</td>
<td>1½&quot;) No. 16 gage noncombustible studs 16&quot; on center with 1/2&quot; cement plaster (measured from the face of the studs) on the exterior surface with interior surface treatment as required for interior, nonbearing, noncombustible stud partitions in this table. Plaster mix 1:4 for scratch coat and 1:5 for brown coat, by volume, cement to sand.</td>
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(Continued)
### TABLE 8.21.1(2)—continued

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>4 hours</td>
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15. Exterior or interior walls (continued)

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<tbody>
<tr>
<td><strong>2’ × 6’ fire-retardant-treated wood studs 16’ on center. Interior face has two layers of 1/4” Type X gypsum with the base layer placed vertically and attached with 8d box nails 12” on center. The face layer is placed horizontally and attached with 8d box nails 8’ on center at joints and 1/2” on center elsewhere. The exterior face has a base layer of 1/4” Type X gypsum sheathing placed vertically with 6d box nails 8’ on center at joints and 1/2” on center elsewhere. An approved building paper is next applied, followed by self-furred exterior lath attached with 2” x 2” gage galvanized roofing nails spaced 6” on center along each stud. Cement plaster consisting of a 1/4” brown coat is then applied. The scratch coat is mixed in the proportion of 1:3 by weight, cement to sand with 10 pounds of hydrated lime and 3 pounds of approved additives or admixtures per sack of cement. The brown coat is mixed in the proportion of 1:4 by weight, cement to sand with the same amounts of hydrated lime and approved additives or admixtures used in the scratch coat.</strong></td>
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<td>15-1.6”</td>
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<tbody>
<tr>
<td><strong>2’ × 6’ wood studs 16’ on center. The exterior face has a layer of 1/4” Type X gypsum sheathing placed vertically with 6d box nails 8’ on center at joints and 1/2” on center elsewhere. An approved building paper is next applied, followed by 1” by No. 18 gage self-furred exterior lath attached with 8d gage 2” long galvanized roofing nails spaced 6” on center along each stud. Cement plaster consisting of a 1/4” scratch coat, a bonding agent and a 1/4” brown coat and a finish coat is then applied. The scratch coat is mixed in the proportion of 1:3 by weight, cement to sand with 10 pounds of hydrated lime and 3 pounds of approved additives or admixtures per sack of cement. The brown coat is mixed in the proportion of 1:4 by weight, cement to sand with the same amounts of hydrated lime and approved additives or admixtures used in the scratch coat. The interior is covered with 1/8” gypsum lath with 1” hexagonal mesh of 0.035 inch (No. 20 B W. gage) woven wire lath furred out 1/4” and 1” perlite or vermiculite gypsum plaster. Lath nailed with 1/4” gage by No. 12 gage by 1/4” head plasterboard glued nails spaced 5” on center. Mesh attached by 1/4” by No. 12 gage by 1/4” head nails with 1/4” furring, spaced 8” on center. The plaster mix shall not exceed 100 pounds of gypsum to 2’/cubic feet of aggregate.</strong></td>
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<tr>
<td>15-1.7”</td>
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<table>
<thead>
<tr>
<th>TABLE 8.21.1(2)—continued</th>
<th>RATED FIRE-RESISTANCE PERIODS FOR VARIOUS WALLS AND PARTITIONS a, o, p</th>
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</thead>
<tbody>
<tr>
<td><strong>MATERIAL</strong></td>
<td><strong>ITEM NUMBER</strong></td>
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<tr>
<td>15.1.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4&quot; No. 18 gage, non-load-bearing metal studs. 16&quot; on center. With 1&quot; Portland cement lime plaster (measured from the back side of the 3/8-pound expanded metal lath) on the exterior surface. Interior surface to be covered with 1/8&quot; of gypsum plaster on 1/4-pound expanded metal lath proportioned by weight-1.2 for scratch coat, 1.3 for brown, gypsum to sand. Lath on one side of the partition fastened to 1/2&quot; diameter pencil nails supported by No. 20 gage metal clips, located 16&quot; on center vertically, on each stud. 3&quot; thick mineral fiber insulating batts friction fitted between the studs.</td>
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<td>15.1.9</td>
<td>Steel studs 0.060&quot; thick, 4&quot; deep or 6&quot; at 16&quot; or 24&quot; centers, with 1/4&quot; Glass Fiber Reinforced Concrete (GFRC) on the exterior surface. GFRC is attached with flex anchors at 24&quot; on center, with 5&quot; leg welded to studs with two 1/2&quot;-long flate-bevel welds, and 4&quot; foot attached to the GFRC skin with 1/4&quot; thick GFRC bonding pads that extend 21/2&quot; beyond the flex anchor foot on both sides. Interior surface to have two layers of 11/8&quot; Type X gypsum wallboard. The first layer of wallboard to be attached with 1&quot;-long Type S buglehead screws spaced 24&quot; on center and the second layer is attached with 11/4&quot;-long Type S screws spaced at 12&quot; on center. Cavity is to be filled with 5&quot; of 4 pcf (nominal) mineral fiber batts. GFRC has 11/2&quot; returns packed with mineral fiber and caulked on the exterior.</td>
</tr>
<tr>
<td>15.1.10</td>
<td>Steel studs 0.060&quot; thick, 4&quot; deep or 6&quot; at 16&quot; or 24&quot; centers, respectively, with 1/4&quot; Glass Fiber Reinforced Concrete (GFRC) on the exterior surface. GFRC is attached with flex anchors at 24&quot; on center, with 5&quot; leg welded to studs with two 1/2&quot;-long flate-bevel welds, and 4&quot; foot attached to the GFRC skin with 1/4&quot; thick GFRC bonding pads that extend 21/2&quot; beyond the flex anchor foot on both sides. Interior surface to have one layer of 11/8&quot; Type X gypsum wallboard, attached with 11/4&quot;-long Type S buglehead screws spaced 12&quot; on center. Cavity is to be filled with 5&quot; of 4 pcf (nominal) mineral fiber batts. GFRC has 11/2&quot; returns packed with mineral fiber and caulked on the exterior.</td>
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<tr>
<td>15.1.11</td>
<td>2&quot; × 6&quot; wood studs at 16&quot; with double top plates, single bottom plate; interior and exterior sides covered with 1/4&quot; Type X gypsum wallboard, 4&quot; wide, applied horizontally or vertically with vertical joints over studs, and fastened with 23/4&quot; Type S drywall screws, spaced 12&quot; on center. Cavity to be filled with 51/2&quot; mineral wool insulation.</td>
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(Continued)
## Table 8.21.1(2)—continued
### RATED FIRE-RESISTANCE PERIODS FOR VARIOUS WALLS AND PARTITIONS a, o, p

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
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<td>4 hours</td>
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<tr>
<td>15-1.12_5</td>
<td>2” x 6” wood studs at 16” on double top plates, single bottom plate; interior and exterior sides covered with 7/8” Type X gypsum wallboard, 4” wide, applied vertically with all joints over framing or blocking and fastened with 2 1/4” Type S drywall screws, spaced 12” on center. R-19 mineral fiber insulation installed in stud cavity.</td>
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<tr>
<td>15-1.14_5</td>
<td>2” x 6” wood studs at 16” on double top plates, single bottom plate; interior and exterior sides covered with 7/8” Type X gypsum wallboard, 4” wide, applied horizontally or vertically with vertical joints over studs, and fastened with 2 1/4” Type S drywall screws, spaced 7” on center.</td>
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<tr>
<td>15-1.15_5</td>
<td>2” x 4” wood studs at 16” on double top plates, single bottom plate; interior and exterior sides covered with 7/8” Type X gypsum wallboard and sheathing, respectively, 4” wide, applied horizontally or vertically with vertical joints over studs, Cavity to be filled with 2 1/4” mineral wool insulation.</td>
<td>—</td>
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<tr>
<td>15-1.16_5</td>
<td>2” x 6” wood studs at 24” centers with double top plates, single bottom plate; interior and exterior side covered with two layers of 7/8” Type X gypsum wallboard, 4” wide, applied horizontally with vertical joints over studs. Base layer fastened with 2 1/4” Type S drywall screws, spaced 24” on center and face layer fastened with Type S drywall screws, spaced 8” on center, wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound. Cavity to be filled with 2 1/4” mineral wool insulation.</td>
<td>—</td>
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<tr>
<td>15-2.1_4</td>
<td>5/8” No. 16 gage steel studs at 24” on center or 2” x 4” wood studs at 24” on center. Metal lath attached to the exterior side of studs at minimum 1” long No. 6 drywall screws at 6” on center and covered with minimum 1/4” thick Portland cement plaster. Thin veneer brick units of clay or shale complying with ASTM C1088, Grade TBS or better, installed in running bond in accordance with Section 1405.10. Combined total thickness of the Portland cement plaster, mortar and thin veneer brick units shall be not less than 1 1/4”. Interior side covered with one layer of 5/8” thick Type X gypsum wallboard attached to studs with 1” long No. 6 drywall screws at 12” on center.</td>
<td>—</td>
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</tr>
<tr>
<td>15-2.2_4</td>
<td>3/4” No. 16 gage steel studs at 24” on center or 2” x 4” wood studs at 24” on center. Metal lath attached to the exterior side of studs at minimum 1” long No. 6 drywall screws at 6” on center and covered with minimum 5/8” thick Portland cement plaster. Thin veneer brick units of clay or shale complying with ASTM C1088, Grade TBS or better, installed in running bond in accordance with Section 1405.10. Combined total thickness of the Portland cement plaster, mortar and thin veneer brick units shall be not less than 2”. Interior side covered with two layers of 3/4” thick Type X gypsum wallboard. Bottom layer attached to studs with 1” long No. 6 drywall screws at 24” on center. Top layer attached to studs with 3/4” long No. 6 drywall screws at 12” on center.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15-2.3_4</td>
<td>3/4” No. 16 gage steel studs at 16” on center or 2” x 4” wood studs at 16” on center. Where metal lath is used, attach to the exterior side of studs at minimum 1” long No. 6 drywall screws at 6” on center. Brick units of clay or shale not less than 2 1/4” thick complying with ASTM C216 installed in accordance with Section 1405.6 with a minimum 1” airspace. Interior side covered with one layer of 3/4” thick Type X gypsum wallboard attached to studs with 1” long No. 6 drywall screws at 12” on center.</td>
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(Continued)
### TABLE 8.21.1(2)—continued

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
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<td>4</td>
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</table>

| 15. Exterior or interior walls | 15-2.4<sup>a</sup> | 3½" No. 16 gage steel studs at 16" on center or 2" x 4" wood studs at 16" on center. Where metal lath is used, attach to the exterior side of studs with minimum 1" long No. 6 drywall screws at 6" on center. Brick units of clay or shale not less than 2½" thick complying with ASTM C216 installed in accordance with Section 1405.6 with a minimum 1" airspace. Interior side covered with two layers of 7/8" thick Type X gypsum wallboard. Bottom layer attached to studs with 1" long No. 6 drywall screws at 34" on center. Top layer attached to studs with 1½" long No. 6 drywall screws at 12" on center. | — | — | 8½ | — |
| 16. Exterior walls rated for fire resistance from the inside only in accordance with Section 705.5. | 16-1.1<sup>b</sup> | 2" x 4" wood studs at 16" centers with double top plates, single bottom plate; interior side covered with 7/8" Type X gypsum wallboard, 4" wide, applied horizontally unblocked, and fastened with 2½" Type S drywall screws, spaced 12" on center, wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound. Exterior covered with 7/8" wood structural panels, applied vertically, horizontal joints blocked and fastened with 6d common nails (bright) — 12" on center in the field, and 6" on center panel edges. Cavity to be filled with 3/4" mineral wool insulation. Rating established for exposure from interior side only. | — | — | 4½ | — |
|          | 16-1.25<sup>c</sup> | 2" x 6" wood studs at 16" centers with double top plates, single bottom plate; interior side covered with 7/8" Type X gypsum wallboard, 4" wide, applied horizontally or vertically with vertical joints over studs and fastened with 2½" Type S drywall screws, spaced 12" on center, wallboard joints covered with paper tape and joint compound, fastener heads covered with joint compound, exterior side covered with 7/8" wood structural panels fastened with 6d common nails (bright) spaced 12" on center in the field and 6" on center along the panel edges. Cavity to be filled with 3/4" mineral wool insulation. Rating established from the gypsum-covered side only. | — | — | 6½ | — |
|          | 16-1.3<sup>d</sup> | 2" x 6" wood studs at 16" centers with double top plates, single bottom plate; interior side covered with 7/8" Type X gypsum wallboard, 4" wide, applied vertically with all joints over framing or blocking and fastened with 2½" Type S drywall screws spaced 7" on center. Joints to be covered with tape and joint compound. Exterior covered with 7/8" wood structural panels, applied vertically with edges over framing or blocking and fastened with 6d common nails (bright) at 12" on center in the field and 6" on center on panel edges. R-19 mineral fiber insulation installed in stud cavity. Rating established from the gypsum-covered side only. | — | — | 6½ | — |

**Note:** For SI: 1 inch = 25.4 mm, 1 square inch = 645.2 mm², 1 cubic foot = 0.0283 m³.

a. Staples with equivalent holding power and penetration shall be permitted to be used as alternate fasteners to nails for attachment to wood framing.

b. Thickness shown for brick and clay tile is nominal thicknesses unless plastered, in which case thicknesses are net. Thickness shown for concrete masonry and clay masonry is equivalent thickness defined in Clause 8.22.3.1 for concrete masonry and Clause 8.22.4.1.1 for clay masonry. Where all cells are solid grouted or filled with silicone-treated perlite loose-fill insulation; vermiculite loose-fill insulation; or expanded clay, shale or slate lightweight aggregate, the equivalent thickness shall be the thickness of the block or brick using specified dimensions as defined in Part 22. Equivalent thickness shall include the thickness of applied plaster and lath or gypsum wallboard, where specified.

c. For units in which the net cross-clausal area of cored brick in any plane parallel to the surface containing the cores is not less than 75 percent of the gross cross-clausal area measured in the same plane.

d. Shall be used for nonbearing purposes only.

e. For all of the construction with gypsum wallboard described in this table, gypsum base for veneer plaster of the same size, thickness and core type shall be permitted to be substituted for gypsum wallboard, provided that attachment is identical to that specified for the wallboard, and the joints on the face layer are reinforced and the entire surface is covered with not less than 1/16-inch gypsum veneer plaster.

f. The fire-resistance time period for concrete masonry units meeting the equivalent thicknesses required for a 2-hour fire-resistance rating in Item 3, and having a thickness of not less than 75/8 inches is 4 hours where cores that are not grouted are filled with silicone-treated perlite loose-fill insulation; vermiculite loose-fill insulation; or expanded clay, shale or slate lightweight aggregate, sand or slag having a maximum particle size of 3/8 inch.

g. The fire-resistance rating of concrete masonry units composed of a combination of aggregate types or where plaster is applied directly to the concrete masonry shall be determined in accordance with this Code. Lightweight aggregates shall have a maximum combined density of 65 pounds per cubic foot.
h. See Note b. The equivalent thickness shall be permitted to include the thickness of cement plaster or 1.5 times the thickness of gypsum plaster applied in accordance with the requirements of Part 26.

i. Concrete walls shall be reinforced with horizontal and vertical temperature reinforcement as required by Part 20.

j. Studs are welded truss wire studs with 0.18 inch (No. 7 B.W. gage) flange wire and 0.18 inch (No. 7 B.W. gage) truss wires.

k. Nailable metal studs consist of two channel studs spot welded back to back with a crimped web forming a nailing groove.

l. Wood structural panels shall be permitted to be installed between the fire protection and the wood studs on either the interior or exterior side of the wood frame assemblies in this table, provided that the length of the fasteners used to attach the fire protection is increased by an amount not less than the thickness of the wood structural panel.

m. For studs with a slenderness ratio, \( l_e/d \), greater than 33, the design stress shall be reduced to 78 percent of allowable \( F_c' \). For studs with a slenderness ratio, \( l_e/d \), not exceeding 33, the design stress shall be reduced to 78 percent of the adjusted stress \( F_c' \) calculated for studs having a slenderness ratio \( l_e/d \) of 33.

n. For properties of cooler or wallboard nails, see ASTM C514, ASTM C547 or ASTM F1667.

o. Generic fire-resistance ratings (those not designated as PROPRIETARY* in the listing) in the GA 600 shall be accepted as if herein listed.

p. NCMA TEK 5-8A shall be permitted for the design of fire walls.

q. The design stress of studs shall be equal to not more than 100 percent of the allowable \( F_c \) calculated in accordance with this Code.

**TABLE 8.21.1(3)**

<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>THICKNESS OF FLOOR OR ROOF SLAB (inches)</th>
<th>MINIMUM THICKNESS OF CEILING (inches)</th>
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</thead>
<tbody>
<tr>
<td>1. Siliceous aggregate concrete</td>
<td>1-1-1</td>
<td>Slab (ceiling not required). Minimum cover over nonprestressed reinforcement shall be not less than ( \frac{3}{4} ).</td>
<td>7.0</td>
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<tr>
<td>2. Carbonate aggregate concrete</td>
<td>2-1-1</td>
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<td>6.6</td>
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<tr>
<td>3. Sand-lightweight concrete</td>
<td>3-1-1</td>
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<td>5.4</td>
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<td>4. Lightweight concrete</td>
<td>4-1-1</td>
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<tr>
<td>5. Reinforced concrete</td>
<td>5-1-1</td>
<td>Slab with suspended ceiling of vermiculite gypsum plaster over metal lath attached to ( \frac{1}{4} ) cold-rolled channels spaced 12&quot; on center. Ceiling located 6&quot; minimum below joists.</td>
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<td>5-2-1</td>
<td>( \frac{1}{4} ) Type X gypsum wallboard attached to 0.018 inch (No. 23 carbon sheet steel gage) by ( \frac{1}{4} ) deep by ( \frac{3}{4} ) hat-shaped galvanized steel channels with 1&quot;-long No. 6 screws. The channels are spaced 24&quot; on center, span 35&quot; and are supported along their length at 35&quot; intervals by 0.033&quot; (No. 21 galvanized sheet gage) galvanized steel flat strap hangers having formed edges that engage the lips of the channel. The strap hangers are attached to the side of the concrete joists with ( \frac{1}{4} ) long power-driven fasteners. The wallboard is installed with the long dimension perpendicular to the channels. End joists occur on channels and supplementary channels are installed parallel to the main channels. 12&quot; each side, at end joint occurrences. The finished ceiling is located approximately 12&quot; below the soffit of the floor slab.</td>
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### Table 8.21.1(3)—continued

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<td>9. 3&quot; deep cellular steel deck with concrete slab on top. Slab thickness measured to top.</td>
<td>9-1.1</td>
<td>Suspended ceiling of vermiculite gypsum plaster base coat and vermiculite acoustical plaster on metal lath attached at 6&quot; intervals to 1/4&quot; cold-rolled channels spaced 12&quot; on center and secured to 1/4&quot; cold-rolled channels spaced 36&quot; on center with 0.065&quot; (No. 16 B.W. gage) wire. 1/4&quot; channels supported by No. 8 gage wire hangers at 36&quot; on center. Beams within envelope and with a 2&quot; airspace between beam soffit and lath have a 4-hour rating.</td>
<td>2 1/4&quot;</td>
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<td>10. 1 1/4&quot; deep steel roof deck on steel framing. Insulation board, 30pcf density, composed of wood fibers with concrete binders of thickness shown bonded to deck with unified asphalt adhesive. Covered with a Class A or B roof covering.</td>
<td>10-1.1</td>
<td>Ceiling of gypsum plaster on metal lath. Lath attached to 1/4&quot; furring channels with 0.045&quot; (No. 18 B.W. gage) wire ties spaced 6&quot; on center. 1/4&quot; channel saddle tied to 2&quot; channels with doubled 0.065&quot; (No. 16 B.W. gage) wire ties. 2&quot; channels spaced 36&quot; on center suspended 2&quot; below steel framing and saddle-tied with 0.165&quot; (No. 8 B.W. gage) wire. Plaster mixed 1:2 by weight, gypsum-to-sand aggregate.</td>
<td>1 1/8&quot;</td>
<td>1/4&quot;</td>
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<tr>
<td>11. 1 1/4&quot; deep steel roof deck on steel framing wood fiber insulation board, 17.5pcf density on top applied over a 15-lb asphalt-saturated felt. Class A or B roof covering.</td>
<td>11-1.1</td>
<td>Ceiling of gypsum plaster on metal lath. Lath attached to 1/4&quot; furring channels with 0.045&quot; (No. 18 B.W. gage) wire ties spaced 6&quot; on center. 1/4&quot; channels saddle tied to 2&quot; channels with doubled 0.065&quot; (No. 16 B.W. gage) wire ties. 2&quot; channels spaced 36&quot; on center suspended 2&quot; below steel framing and saddle-tied with 0.165&quot; (No. 8 B.W. gage) wire. Plaster mixed 1:2 for scratch coat and 1:3 for brown coat, by weight, gypsum-to-sand aggregate for 1-hour system. For 2-hour system, plaster mix is 1:2 by weight, gypsum-to-sand aggregate.</td>
<td>1 1/2&quot;</td>
<td>1/4&quot;</td>
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(Continued)
### TABLE 8.21.1(3)—continued

**MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS**

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<th>MINIMUM THICKNESS OF CEILING (inches)</th>
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<tbody>
<tr>
<td>12. 1/2&quot; deep steel roof deck on steel-framing insulation of rigid board consisting of expanded perlite and fibers impregnated with integral asphalt waterproofing; density of 9 to 12pcf secured to metal roof deck by 1/2&quot; wide ribbons of waterproof, cold-process liquid adhesive spaced 6&quot; apart. Steel joist or light steel construction with metal roof deck, insulation, and Class A or B built-up roof covering.</td>
<td>12-1.1</td>
<td>Gypsum-vermiculite plaster on metal lath wire tied at 6&quot; intervals to 1/2&quot; furring channels spaced 12&quot; on center and wire tied to 2&quot; runner channels spaced 32&quot; on center. Runners wire tied to bottom chord of steel joists.</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>13. Double wood floor over wood joists spaced 16&quot; on center.</td>
<td>13-1.1</td>
<td>Gypsum plaster over 1/2&quot; Type X gypsum lath. Lath initially applied with not less than four 1/4&quot; by No. 13 gage by 1/2&quot; head plasterboard blued nails per bearing. Continuous stripping over lath along all joint lines. Stripping consists of 3&quot; wide strips of metal lath attached by 1/8&quot; by No. 11 gage by 1/2&quot; head roofing nails spaced 6&quot; on center. Alternate stripping consists of 3&quot; wide 0.049&quot; diameter wire stripping weighing 1 pound per square yard and attached by No.16 gage by 1/2&quot; by 1/4&quot; crown width staples, spaced 4&quot; on center. Where alternate stripping is used, the lath nailing shall consist of two nails at each end and one nail at each intermediate bearing. Plaster mixed 1:2 by weight, gypsum-to-sand aggregate.</td>
<td>—</td>
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<tr>
<td>13-1.2</td>
<td>Cement or gypsum plaster on metal lath. Lath fastened with 1/2&quot; by No. 11 gage by 3/16&quot; head barbed shank roofing nails spaced 5&quot; on center. Plaster mixed 1:2 for scratch coat and 1:3 for brown coat, by weight, cement to sand aggregate.</td>
<td>—</td>
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<tr>
<td>13-1.3</td>
<td>Perlite or vermiculite gypsum plaster on metal lath secured to joists with 1/2&quot; by No. 11 gage by 1/4&quot; head barbed shank roofing nails spaced 5&quot; on center.</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>13-1.4</td>
<td>1/2&quot; Type X gypsum wallboard nailed to joists with 5d cooler or wallboard nails at 6&quot; on center. End joints of wallboard centered on joists.</td>
<td>—</td>
<td>—</td>
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(Continued)
### TABLE 8.21.1(3)—continued

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<tr>
<td></td>
<td></td>
<td></td>
<td>4 hours 3 hours 2 hours 1 hour</td>
<td>4 hours 3 hours 2 hours 1 hour</td>
</tr>
<tr>
<td>14. Plywood</td>
<td>14-1.1</td>
<td>1/4&quot;-thick wood fiberboard weighing 15 to 18 pounds per cubic foot installed with long dimension parallel to stringers and/or nailed to stringers. Nailing to be with 5d cooper or wallboard nails at 12&quot; on center. Second layer of 1/2&quot; Type X gypsum wallboard applied with long dimension perpendicular to joints and attached with 8d cooper or wallboard nails at 6&quot; on center at end joints and 8&quot; on center elsewhere. Wallboard joints staggered with respect to fiberboard joints.</td>
<td>— — — —</td>
<td>— — — —</td>
</tr>
<tr>
<td>15. Vermiculite concrete slab proportioned 1:4 (Portland cement to vermiculite aggregate) on a 1/2&quot;-deep steel deck supported on individually protected steel framing. Maximum span of deck 6'-10&quot; where deck is less than 0.019 inch (No. 26 carbon steel sheet gage) or greater. Slab reinforced with 4&quot;x8&quot; G.109/0.083&quot; (No. 13/8, B.W. gage) welded wire mesh.</td>
<td>15-1.1 None</td>
<td>— — — — 3&quot;</td>
<td>— — — —</td>
<td></td>
</tr>
<tr>
<td>16. Perlite concrete slab proportioned 1:6 (Portland cement to perlite aggregate) on a 1/2&quot;-deep steel deck supported on individually protected steel framing. Slab reinforced with 4&quot;x8&quot; G.109/0.083&quot; (No. 13/8, B.W. gage) welded wire mesh.</td>
<td>16-1.1 None</td>
<td>— — — — 3/4&quot;</td>
<td>— — — —</td>
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### TABLE 8.21.1(3)—continued

#### MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS

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<th>CEILING CONSTRUCTION</th>
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<th>MINIMUM THICKNESS OF CEILING (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17. Perlite concrete slab proportioned 1:6 (Portland cement to perlite aggregate) on a 3(\frac{3}{8})&quot;-deep steel deck supported by steel joists 4' on center. Class A or B roof covering on top.</td>
<td>17-1.1</td>
<td>Perlite gypsum plaster on metal lath wire tied to (\frac{1}{4}), furring channels attached with 0.065&quot; (No. 16 B.W. gage) wire tied to lower chord of joists.</td>
<td>-</td>
<td>(\frac{3}{8})</td>
</tr>
<tr>
<td>18. Perlite concrete slab proportioned 1:6 (Portland cement to perlite aggregate) on 1(\frac{1}{4})&quot;-deep steel deck supported on individually protected steel framing. Maximum span of deck 6'-10&quot; where deck is less than 0.015&quot; (No. 25 carbon steel sheet gage) and 8'-0&quot; where deck is 0.019&quot; (No. 26 carbon sheet steel gage) or greater. Slab reinforced with 0.042&quot; (No. 19 B.W. gage) hexagonal wire mesh. Class A or B roof covering on top.</td>
<td>18-1.1</td>
<td>None</td>
<td>-</td>
<td>(\frac{3}{4})</td>
</tr>
<tr>
<td>19. Floor and beam construction consisting of 3(\frac{1}{2})&quot; deep cellular steel floor unit mounted on steel members with 1:4 (proportion of Portland cement to perlite aggregate) perlite-concrete floor slab on top.</td>
<td>19-1.1</td>
<td>Suspended envelope ceiling of perlite gypsum plaster on metal lath attached to (\frac{1}{4}), cold-rolled channels, secured to 1(\frac{1}{4})&quot; cold-rolled channels spaced 42&quot; on center supported by 0.203 inch (No. 6 B.W. gage) wire spaced 36&quot; on center. Beams in envelope with 3&quot; minimum airspace between beam soffit and lath have a 4-hour rating.</td>
<td>2&quot;</td>
<td>-</td>
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TABLE 8.21.1(3)—continued
MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS

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<tbody>
<tr>
<td></td>
<td></td>
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<td>4 hours</td>
<td>3 hours</td>
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<tr>
<td>20. Perlite concrete proportioned 1:6 (Portland cement to perlite aggregate) poured to ( \frac{3}{4}'' ) thickness above top of corrugations of ( \frac{1}{3}'' ) deep galvanized steel deck maximum span 8'-0&quot; for 0.024&quot; (No. 24 galvanized sheet gage) or 6'-0&quot; for 0.019&quot; (No. 26 galvanized sheet gage) with deck supported by individually protected steel framing. Approved polystyrene foam plastic insulation board having a flame spread not exceeding 75 (1&quot; to 4&quot; thickness) with vent holes that approximate 5 percent of the board surface area placed on top of perlite slurry. A 2&quot; by 4&quot; insulation board contains six ( \frac{3}{4}'' ) diameter holes. Board covered with ( \frac{1}{4}'' ) minimum perlite concrete slab. Slab reinforced with mesh consisting of 0.042&quot; (No. 19 B.W. gage) galvanized steel wire twisted together to form 2&quot; hexagons with straight 0.065&quot; (No. 16 B.W. gage) galvanized steel wire woven into mesh and spaced 3&quot;. Alternate slab reinforcement shall be permitted to consist of 4&quot; ( \times ) 8&quot;, 0.109/0.238&quot; (No. 12/4 B.W. gage), or 2&quot; ( \times ) 2&quot;, 0.083/0.083&quot; (No. 14/14 B.W. gage) welded wire fabric Class A or B roof covering on top.</td>
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<td></td>
<td>20-1.1</td>
<td>None</td>
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<tr>
<td>21. Wood joists, wood I-joists, floor trusses and flat or pitted roof trusses spaced a maximum 24&quot; o.c. with ( \frac{1}{4}'' ) wood structural panels with exterior glue applied at right angles to top of joist or top chord of trusses with 8d nails. The wood structural panel thickness shall be less than nominal ( \frac{1}{2}'' ) nor less than required by Chapter 23.</td>
<td></td>
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<td></td>
<td>21-1.1</td>
<td>Base layer ( \frac{1}{4}'' ) Type X gypsum wallboard applied at right angles to joint or truss 24&quot; o.c. with ( \frac{1}{4}'' ) Type S or Type W drywall screws 24&quot; o.c. Face layer ( \frac{1}{4}'' ) Type X gypsum wallboard or veneer base applied at right angles to joint or truss through base layer with ( \frac{1}{2}'' ) Type S or Type W drywall screws 12&quot; o.c. at joints and intermediate joint or truss. Face layer Type G drywall screws placed 2&quot; back on either side of face layer end joints, 12&quot; o.c.</td>
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<td></td>
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<td>4 hours</td>
<td>3 hours</td>
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<tr>
<td>22. Steel joists, floor tusses and flat or pitched roof tusses spaced a maximum 24&quot; o.c. with 1/2&quot; wood structural panels with exterior glue applied at right angles to top of joist or top chord of trusses with No. 8 screws. The wood structural panel thickness shall be not less than nominal 1/4&quot; nor less than required by Chapter 23.</td>
<td>22-1.1</td>
<td>Base layer 1/4&quot; Type X gypsum board applied at right angles to steel framing 24&quot; on center with 1&quot; Type S drywall screws spaced 24&quot; on center. Face layer 1/2&quot; Type X gypsum board applied at right angles to steel framing attached through base layer with 1/2&quot; Type S drywall screws 12&quot; on center at end joints and intermediate joints and 1/4&quot; Type G drywall screws 12 inches on center placed 2&quot; back on either side of face layer end joints. Joints of the face layer are offset 24&quot; from the joints of the base layer.</td>
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<tr>
<td>23. Wood l-joint (minimum joist depth 9/16&quot; with a minimum flange depth of 1/4&quot; and a minimum flange cross-sectional area of 2.25 square inches) at 24&quot; o.c. spacing with a minimum 1 x 4 (3/4&quot; x 3 1/2&quot; actual) ledger strip applied parallel to and covering the bottom of the bottom flange of each member, tacked in place. 2&quot; mineral wool insulation, 3 1/4 pc (nominal) installed adjacent to the bottom flange of the l-joint and supported by the 1 x 4 ledger strip.</td>
<td>23-1.1</td>
<td>1/2&quot; deep single leg resilient channel 16&quot; on center (channels doubled at wallboard end joints), placed perpendicular to the furring strip and joist and attached to each joist by 1/4&quot; Type S drywall screws. 1/2&quot; Type C gypsum wallboard applied perpendicular to the channel with end joints staggered not less than 4&quot; and fastened with 1/4&quot; Type S drywall screws spaced 12&quot; on center. Wallboard joints to be taped and covered with joint compound.</td>
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<tr>
<td>24. Wood l-joint (minimum joist depth 9/16&quot; with a minimum flange depth of 1/4&quot; and a minimum flange cross-sectional area of 5.25 square inches; minimum web thickness of 1/4&quot; @ 24&quot; o.c.; 1/4&quot; mineral wool insulation (2.5 pc-nominal) resting on hat-shaped furring channels.</td>
<td>24-1.1</td>
<td>Minimum 0.026&quot; thick hat-shaped channel 16&quot; o.c. (channels doubled at wallboard end joints), placed perpendicular to the joist and attached to each joist by 1/4&quot; Type S drywall screws. 1/2&quot; Type C gypsum wallboard applied perpendicular to the channel with end joints staggered and fastened with 1/4&quot; Type S drywall screws spaced 12&quot; o.c. in the field and 8&quot; o.c. at the wallboard ends. Wallboard joints to be taped and covered with joint compound.</td>
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<tr>
<td>25. Wood l-joint (minimum joist depth 9/16&quot; with a minimum flange depth of 1/4&quot; and a minimum flange cross-sectional area of 5.25 square inches; minimum web thickness of 1/4&quot; @ 24&quot; o.c.; 1/4&quot; mineral wool insulation (2.5 pc-nominal) resting on resilient channels.</td>
<td>25-1.1</td>
<td>Minimum 0.019&quot; thick resilient channel 16&quot; o.c. (channels doubled at wallboard end joints), placed perpendicular to the joist and attached to each joist by 1/4&quot; Type S drywall screws. 1/2&quot; Type C gypsum wallboard applied perpendicular to the channel with end joints staggered and fastened with 1&quot; Type S drywall screws spaced 12&quot; o.c. in the field and 8&quot; o.c. at the wallboard ends. Wallboard joints to be taped and covered with joint compound.</td>
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(Continued)
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<td></td>
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<td>3 hours</td>
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<td>25. Wood I-joist (minimum I-joist depth 9'/4&quot;, with a minimum flange thickness of 1'/4&quot; and a minimum flange cross-sectional area of 2.25 square inches; minimum web thickness of 3/8&quot;) @ 24&quot; o.c.</td>
<td>26-1.1</td>
<td>Two layers of 1'/4&quot; Type X gypsum wallboard applied with the long dimension perpendicular to the I-joists with end joints staggered. The base layer is fastened with 1'/4&quot; Type S drywall screws spaced 12&quot; o.c. and the face layer is fastened with 2&quot; Type S drywall screws spaced 12&quot; o.c. in the field and 8&quot; o.c. on the edges. Face layer end joints shall not occur on the same I-joist as base layer end joints and edge joints shall be offset 24&quot; from base layer joints. Face layer to also be attached to base layer with 1'/4&quot; Type G drywall screws spaced 8&quot; o.c. placed 6&quot; from face layer end joints. Face layer wallboard joints to be taped and covered with joint compound.</td>
<td>—</td>
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<tr>
<td>27. Wood I-joist (minimum I-joist depth 9'/4&quot;, with a minimum flange depth of 1'/4&quot; and a minimum flange cross-sectional area of 1.95 square inches; minimum web thickness of 3/8&quot;) @ 24&quot; o.c.</td>
<td>27-1.1</td>
<td>Minimum 0.019&quot; thick resilient channel 16&quot; o.c. (channels doubled at wallboard end joints), placed perpendicular to the joist and attached to each joist by 1'/4&quot; Type S drywall screws. Two layers of 1'/4&quot; Type X gypsum wallboard applied with the long dimension perpendicular to the resilient channels with end joints staggered. The base layer is fastened with 1'/4&quot; Type S drywall screws spaced 12&quot; o.c. and the face layer is fastened with 1'/4&quot; Type S drywall screws spaced 12&quot; o.c. Face layer end joints shall not occur on the same I-joist as base layer end joints and edge joints shall be offset 24&quot; from base layer joints. Face layer to also be attached to base layer with 1'/4&quot; Type G drywall screws spaced 8&quot; o.c. placed 6&quot; from face layer end joints. Face layer wallboard joints to be taped and covered with joint compound.</td>
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<tr>
<td>28. Wood L-joint (minimum L-joint depth $9\frac{1}{2}''$, with a minimum flange depth of $1\frac{3}{4}$ and a minimum flange cross-sectional area of 2.25 square inches; minimum web thickness of $\frac{1}{4}''$) @ 24 o.c. Unfaced fiberglass insulation or mineral wool insulation is installed between the L-joints supported on the upper surface of the flange by stay wires spaced 12'' o.c.</td>
<td>28-1.1</td>
<td>Base layer $\frac{1}{2}''$ Type C gypsum wallboard attached directly to L-joints with $1\frac{1}{4}''$ Type S drywall screws spaced 12'' o.c. with ends staggered. Minimum 0.0179'' thick hat-shaped $\frac{1}{2}''$-inch furring channel 16'' o.c. (Channels doubled at wallboard end joints), placed perpendicular to the joint and attached to each joint by $1\frac{1}{4}''$ Type S drywall screws after the base layer of gypsum wallboard has been applied. The middle and face layers of $\frac{1}{2}''$ Type C gypsum wallboard applied perpendicular to the channel with end joints staggered. The middle layer is fastened with $1''$ Type S drywall screws spaced 12'' o.c. The face layer is applied parallel to the middle layer but with the edge joints offset 24'' from those of the middle layer and fastened with $1\frac{1}{4}''$ Type S drywall screws 8'' o.c. The joints shall be taped and covered with joint compound.</td>
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<tr>
<td>29. Channel-shaped 18 gauge steel joints (minimum depth 8'') spaced a maximum 24'' o.c. supporting tongue-and-groove wood structural panels (nominal minimum $\frac{1}{4}''$ thick) applied perpendicular to framing members. Structural panels attached with $1\frac{1}{4}''$ Type S-12 screws spaced 12'' o.c.</td>
<td>29-1.1</td>
<td>Base layer $\frac{1}{2}''$ Type X gypsum board applied perpendicular to bottom of framing members with $1\frac{1}{4}''$ Type S-12 screws spaced 12'' o.c. Second layer $\frac{1}{2}''$ Type X gypsum board attached perpendicular to framing members with $1\frac{1}{4}''$ Type S-12 screws spaced 12'' o.c. Second layer joints offset 24'' from base layer. Third layer $\frac{1}{2}''$ Type X gypsum board attached perpendicular to framing members with $2\frac{1}{8}''$ Type S-12 screws spaced 12'' o.c. Third layer joints offset 12'' from second layer joints. Hat-shaped $\frac{1}{8}''$-inch rigid furring channels applied at right angles to framing members over third layer with two $2\frac{1}{8}''$ Type S-12 screws at each framing member. Face layer $\frac{1}{4}''$ Type X gypsum board applied at right angles to furring channels with $1\frac{1}{4}''$ Type S screws spaced 12'' o.c.</td>
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<td></td>
<td>Minimum 0.019&quot; thick resilient channel 16&quot; o.c. (channels doubled at wallboard end joints), placed perpendicular to the joists and attached to each joist by 1 / 4 Type S drywall screws. Two layers of 1 / 2 Type X gypsum wallboard applied with the long dimension perpendicular to the resilient channels with end joints staggered. The base layer is fastened with 1 / 4 Type S drywall screws spaced 12&quot; o.c. and the face layer is fastened with 1 / 8 Type S drywall screws spaced 12&quot; o.c. Face layer end joints shall not occur on the same I-joist as base layer end joints and edge joints shall be offset 24&quot; from base layer joints. Face layer to be attached to base layer with 1 / 2 Type G drywall screws spaced 8&quot; o.c. placed 6&quot; from face layer end joints. Face layer wallboard joints to be taped and covered with joint compound.</td>
<td>4 hours</td>
<td>3 hours</td>
</tr>
<tr>
<td>30. Wood I-joist (minimum I-joist depth 9 / 2&quot; with a minimum flange depth of 1 / 2&quot; and a minimum flange cross-clauseal area of 2.25 square inches; minimum web thickness of 3 / 8&quot;)</td>
<td>30-1.1</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
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Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 0.454 kg, 1 cubic foot = 0.0283 m³, 1 pound per square inch = 6.895 kPa, 1 pound per linear foot = 1.4882 kg/m.

1. Staples with equivalent holding power and penetration shall be permitted to be used as alternate fasteners to nails for attachment to wood framing.
b. Where the slab is in an unrestrained condition, minimum reinforcement cover shall be not less than 15/8 inches for 4 hours (siliceous aggregate only); 11/4 inches for 3 hours; 1 inch for 2 hours (siliceous aggregate only); and 3/4 inch for all other restrained and unrestrained conditions.

c. For all of the construction with gypsum wallboard described in this table, gypsum base for veneer plaster of the same size, thickness and core type shall be permitted to be substituted for gypsum wallboard, provided that attachment is identical to that specified for the wallboard, and the joints on the face layer are reinforced and the entire surface is covered with not less than 1/16-inch gypsum veneer plaster.

d. Slab thickness over steel joists measured at the joists for metal lath form and at the top of the form for steel form units.

e. (a) The maximum allowable stress level for H-Series joists shall not exceed 22,000 psi.

(b) The allowable stress for K-Series joists shall not exceed 26,000 psi, the nominal depth of such joist shall be not less than 10 inches and the nominal joist weight shall be not less than 5 pounds per linear foot.

f. Cement plaster with 15 pounds of hydrated lime and 3 pounds of approved additives or admixtures per bag of cement.

g. Gypsum wallboard ceilings attached to steel framing shall be permitted to be suspended with 11/2-inch cold-formed carrying channels spaced 48 inches on center, that are suspended with No. 8 SWG galvanized wire hangers spaced 48 inches on center. Cross-furring channels are tied to the carrying channels with No. 18 SWG galvanized wire hangers spaced 48 inches on center. Cross-furring channels are tied to the carrying channels with No. 18 SWG galvanized wire (double strand) and spaced as required for direct attachment to the framing. This alternative is applicable to those steel framing assemblies recognized under Note q.

h. Six-inch hollow clay tile with 2-inch concrete slab above.

i. Four-inch hollow clay tile with 11/2-inch concrete slab above.

j. Thickness measured to bottom of steel form units.

k. Five-eighths inch of vermiculite gypsum plaster plus 1/2 inch of approved vermiculite acoustical plastic.

l. Furring channels spaced 12 inches on center.

m. Double wood floor shall be permitted to be either of the following:

(a) Subfloor of 1-inch nominal boarding, a layer of asbestos paper weighing not less than 14 pounds per 100 square feet and a layer of 1-inch nominal tongue-and-groove finished flooring.

(b) Subfloor of 1-inch nominal tongue-and-groove boarding or 15/32-inch wood structural panels with exterior glue and a layer of 1-inch nominal tongue-and-groove finished flooring or 19/32-inch wood structural panel finish flooring or a layer of Type I Grade M-1 particleboard not less than 5/8-inch thick.

n. The ceiling shall be permitted to be omitted over unusable space, and flooring shall be permitted to be omitted where unusable space occurs above.

o. For properties of cooler or wallboard nails, see ASTM C514, ASTM C547 or ASTM F1667.

p. Thickness measured on top of steel deck unit.

q. Generic fire-resistance ratings (those not designated as PROPRIETARY™ in the listing) in the GA 600 shall be accepted as if herein listed.

8.21.1.1 Thickness of protective coverings.

The thickness of fire-resistant materials required for protection of structural members shall be not less than set forth in Table 8.21.1(1), except as modified in this clause. The figures shown shall be the net thickness of the protecting materials and shall not include any hollow space in back of the protection.

8.21.1.2 Unit masonry protection.

Where required, metal ties shall be embedded in bed joints of unit masonry for protection of steel columns. Such ties shall be as set forth in Table 8.21.1(1) or be equivalent thereto.

8.21.1.3 Reinforcement for cast-in-place concrete column protection.

Cast-in-place concrete protection for steel columns shall be reinforced at the edges of such members with wire ties of not less than 4.6 mm (0.18 inch) in diameter wound spirally around the columns on a pitch of not more than 203 mm (8 inches) or by equivalent reinforcement.

8.21.1.4 Plaster application.
The finish coat is not required for plaster protective coatings where those coatings comply with the design mix and thickness requirements of Tables 8.21.1(1), 8.21.1(2) and 8.21.1(3).

8.21.1.5 Bonded prestressed concrete tendons.

For members having a single tendon or more than one tendon installed with equal concrete cover measured from the nearest surface, the cover shall be not less than that set forth in Table 8.21.1(1). For members having multiple tendons installed with variable concrete cover, the average tendon cover shall be not less than that set forth in Table 8.21.1(1), provided that:

1. The clearance from each tendon to the nearest exposed surface is used to determine the average cover.

2. The clear cover for individual tendons shall not be less than one-half of that set forth in Table 8.21.1(1). A minimum cover of 19.1 mm (3/4 inch) for slabs and 25 mm (1 inch) for beams is required for any aggregate concrete

3. For the purpose of establishing a fire-resistance rating, tendons having a clear covering less than that set forth in Table 8.21.1(1) shall not contribute more than 50 percent of the required ultimate moment capacity for members less than 0.226 m² (350 square inches) in cross-clausal area and 65 percent for larger members. For structural design purposes, however, tendons having a reduced cover are assumed to be fully effective.

8.22 CALculated fire resistance

8.22.1 General.

The provisions of this clause contain procedures by which the fire resistance of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this clause and shall not be otherwise used. The calculated fire resistance of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with this Code. The calculated fire resistance of steel assemblies shall be permitted in accordance with Part 5 of ASCE 29. The calculated fire resistance of exposed wood members and wood decking shall be permitted in accordance with this Code.

8.22.2 Concrete assemblies.

The provisions of this clause contain procedures by which the fire-resistance ratings of concrete assemblies are established by calculations.

8.22.2.1 Concrete walls.

Cast-in-place and precast concrete walls shall comply with Clause 8.22.2.1.1. Multiwythe concrete walls shall comply with Clause 8.22.2.1.2. Joints between precast panels shall comply with Clause 8.22.2.1.3. Concrete walls with gypsum wallboard or plaster finish shall comply with Clause 8.22.2.1.4.

8.22.2.1.1 Cast-in-place or precast walls.

The minimum equivalent thicknesses of cast-in-place or precast concrete walls for fire-resistance ratings of 1 hour to 4 hours are shown in Table 8.22.2.1.1. For solid walls with flat vertical surfaces, the equivalent thickness is the same as the actual thickness. The values in Table 8.22.2.1.1 apply to plain, reinforced or prestressed concrete walls.

<table>
<thead>
<tr>
<th>CONCRETE TYPE</th>
<th>MINIMUM SLAB THICKNESS (inches) FOR FIRE-RESISTANCE RATING OF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td>Siliceous</td>
<td>3.5</td>
</tr>
<tr>
<td>Carbonate</td>
<td>3.2</td>
</tr>
<tr>
<td>Sand-lightweight</td>
<td>2.7</td>
</tr>
<tr>
<td>Lightweight</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.
8.22.2.1.1 Hollow-core precast wall panels.

For hollow-core precast concrete wall panels in which the cores are of constant cross clause throughout the length, calculation of the equivalent thickness by dividing the net cross-clausal area (the gross cross clause minus the area of the cores) of the panel by its width shall be permitted.

8.22.2.1.2 Core spaces filled.

Where all of the core spaces of hollow-core wall panels are filled with loose-fill material, such as expanded shale, clay or slag, or vermiculite or perlite, the fire-resistance rating of the wall is the same as that of a solid wall of the same concrete type and of the same overall thickness.

8.22.2.1.3 Tapered cross clauses.

The thickness of panels with tapered cross clauses shall be that determined at a distance 2t or 6 inches (152 mm), whichever is less, from the point of minimum thickness, where t is the minimum thickness.

8.22.2.1.4 Ribbed or undulating surfaces.

The equivalent thickness of panels with ribbed or undulating surfaces shall be determined by one of the following expressions:

For \( s \geq 4t \), the thickness to be used shall be \( t \)

For \( s \leq 2t \), the thickness to be used shall be \( t_e \)

For \( 4t > s > 2t \), the thickness to be used shall be

\[
\text{(Equation 8-3)}
\]

where:

\( s \) = Spacing of ribs or undulations.

8.22.2.1.2 Multiwythe walls.

For walls that consist of two wythes of different types of concrete, the fire-resistance ratings shall be permitted to be determined from Figure 8.22.2.1.2.

\[
t = \text{Minimum thickness.}
\]

\[
t_e = \text{Equivalent thickness of the panel calculated as the net cross-clausal area of the panel divided by the width, in which the maximum thickness used in the calculation shall not exceed } 2t.
\]

---

**FIGURE 8.22.2.1.2 FIRE-RESISTANCE RATINGS OF TWO-WYTHE CONCRETE WALLS**

**TABLE 8.22.2.1.2(1) VALUES OF Rn0.59 FOR USE IN EQUATION 7-4**

<table>
<thead>
<tr>
<th>TYPE OF MATERIAL</th>
<th>THICKNESS OF MATERIAL (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/2</td>
</tr>
<tr>
<td>Siliceous aggregate concrete</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Carbonate aggregate concrete | 5.5 | 7.1 | 8.9 | 10.4 | 12.0 | 14.0 | 16.2 | 18.1 | 20.3 | 21.9 | 24.7 | 27.2
Sand-lightweight concrete | 6.5 | 8.2 | 10.5 | 12.8 | 15.5 | 18.1 | 20.7 | 23.3 | 26.0 | Note c | Note c | Note c
Lightweight concrete | 6.6 | 8.8 | 11.2 | 13.7 | 16.5 | 19.1 | 21.9 | 24.7 | 27.8 | Note c | Note c | Note c
Insulating concrete a | 9.3 | 13.3 | 16.6 | 18.3 | 23.1 | 26.5 | Note c | Note c | Note c | Note c | Note c | Note c
Airspace b | — | — | — | — | — | — | — | — | — | — | — | —

Note: For SI: 1 inch = 25.4 mm, 1 pound per cubic foot = 16.02 kg/m3.

Table 8.22.2.1.2(2).

8.22.2.1.2 Foam plastic insulation.

The fire-resistance ratings of precast concrete wall panels consisting of a layer of foam plastic insulation sandwiched between two wythes of concrete shall be permitted to be determined by use of Equation 8-4. Foam plastic insulation with a total thickness of less than 1 inch (25 mm) shall be disregarded. The Rn value for thickness of foam plastic insulation of 1 inch (25 mm) or greater, for use in the calculation, is 5 minutes; therefore Rn0.59 = 2.5.

8.22.2.1.3 Joints between precast wall panels.

Joints between precast concrete wall panels that are not insulated as required by this clause shall be considered as openings in walls. Uninsulated joints shall be included in determining the percentage of openings permitted by Table 8.5.8. Where openings are not permitted or are required by this Code to be protected, the provisions of this clause shall be used to determine the amount of joint insulation required. Insulated joints shall not be considered openings for purposes of determining compliance with the allowable percentage of openings in Table 8.5.8.

8.22.2.1.3.1 Ceramic fiber joint protection.

Figure 722.2.1.3.1 shows thicknesses of ceramic fiber blankets to be used to insulate joints between precast concrete wall panels for various panel thicknesses and for joint widths of 3/8 inch (9.5 mm) and 1 inch (25 mm) for fire-resistance ratings of 1 hour to 4 hours. For joint widths between 3/8 inch (9.5 mm) and 1 inch (25 mm), the thickness of ceramic fiber blanket is allowed to be determined by direct interpolation. Other tested and labeled materials are acceptable in place of ceramic fiber blankets.
8.22.2.1.4 Walls with gypsum wallboard or plaster finishes.

The fire-resistance rating of cast-in-place or precast concrete walls with finishes of gypsum wallboard or plaster applied to one or both sides shall be permitted to be calculated in accordance with the provisions of this clause.

### TABLE 8.22.2.1.4(1) MULTIPLYING FACTOR FOR FINISHES ON NON FIREEXPOSED SIDE OF WALL

<table>
<thead>
<tr>
<th>TYPE OF FINISH APPLIED TO CONCRETE OR CONCRETE MASONRY WALL</th>
<th>TYPE OF AGGREGATE USED IN CONCRETE OR CONCRETE MASONRY</th>
<th>( \text{CONCRETE: sand-lightweight} )</th>
<th>( \text{Concrete: sand-lightweight} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland cement-sand plaster</td>
<td>Concrete: siliceous or carbonate Concrete Masonry: siliceous or carbonate; solid clay brick</td>
<td>1.00</td>
<td>0.75(^a)</td>
</tr>
<tr>
<td>Gypsum-sand plaster</td>
<td>Concrete Masonry: clay tile; hollow clay brick; concrete masonry units of expanded shale and &lt; 20% sand</td>
<td>0.75(^a)</td>
<td>0.50(^a)</td>
</tr>
<tr>
<td>Gypsum-vermiculite or perlite plaster</td>
<td>Concrete Masonry: concrete masonry units of expanded shale, expanded clay, expanded slag, or pumice &lt; 20% sand</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>Gypsum wallboard</td>
<td>Concrete Masonry: concrete masonry units of expanded slag, expanded clay, or pumice</td>
<td>2.25</td>
<td>2.25</td>
</tr>
</tbody>
</table>

\( \text{PORTLAND CEMENT-\textit{SAND}} \) | 1.00 | 0.75 | 0.75 |
| \( \text{GYPSUM-SAND} \) | 1.25 | 1.00 | 1.00 |
| \( \text{GYPSUM-VERMICULITE OR PERLITE} \) | 1.75 | 1.50 | 1.25 |
| \( \text{GYPSUM WALLBOARD} \) | 3.00 | 2.25 | 2.25 |

Note: For SI: 1 inch = 25.4 mm.

\(^a\) For Portland cement-sand plaster 5/8 inch or less in thickness and applied directly to the concrete or concrete masonry on the nonfire-exposed side of the wall, the multiplying factor shall be 1.00.
# TABLE 8.22.2.1.4(2) TIME ASSIGNED TO FINISH MATERIALS ON FIRE-EXPOSED SIDE OF WALL

<table>
<thead>
<tr>
<th>FINISH DESCRIPTION</th>
<th>TIME (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum wallboard</td>
<td></td>
</tr>
<tr>
<td>3/8 inch</td>
<td>10</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>15</td>
</tr>
<tr>
<td>5/8 inch</td>
<td>20</td>
</tr>
<tr>
<td>2 layers of 3/8 inch</td>
<td>25</td>
</tr>
<tr>
<td>1 layer of 3/8 inch, 1 layer of 1/2 inch</td>
<td>35</td>
</tr>
<tr>
<td>2 layers of 1/2 inch</td>
<td>40</td>
</tr>
<tr>
<td>Type X gypsum wallboard</td>
<td></td>
</tr>
<tr>
<td>1/2 inch</td>
<td>25</td>
</tr>
<tr>
<td>5/8 inch</td>
<td>40</td>
</tr>
<tr>
<td>Portland cement-sand plaster applied directly to concrete masonry</td>
<td>See Note a</td>
</tr>
<tr>
<td>Portland cement-sand plaster on metal lath</td>
<td></td>
</tr>
<tr>
<td>3/4 inch</td>
<td>20</td>
</tr>
<tr>
<td>7/8 inch</td>
<td>25</td>
</tr>
<tr>
<td>1 inch</td>
<td>30</td>
</tr>
<tr>
<td>Gypsum sand plaster on 3/8-inch gypsum lath</td>
<td></td>
</tr>
<tr>
<td>1/2 inch</td>
<td>35</td>
</tr>
<tr>
<td>5/8 inch</td>
<td>40</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>50</td>
</tr>
<tr>
<td>Gypsum sand plaster on metal lath</td>
<td></td>
</tr>
<tr>
<td>3/4 inch</td>
<td>50</td>
</tr>
<tr>
<td>7/8 inch</td>
<td>60</td>
</tr>
<tr>
<td>1 inch</td>
<td>80</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm.

**a.** The actual thickness of Portland cement-sand plaster, provided that it is 5/8 inch or less in thickness, shall be permitted to be included in determining the equivalent thickness of the masonry for use in Table 8.22.3.2.

## 8.22.2.1.4.1 Nonfire-exposed side.

Where the finish of gypsum wallboard or plaster is applied to the side of the wall not exposed to fire, the contribution of the finish to the total fire-resistance rating shall be determined as follows: The thickness of the finish shall first be corrected by multiplying the actual thickness of the finish by the applicable factor determined from Table 8.22.2.1.4(1) based on the type of
aggregate in the concrete. The corrected thickness of finish shall then be added to the actual or equivalent thickness of concrete and fire-resistance rating of the concrete and finish determined from Tables 8.22.2.1.1 and 8.22.2.1.2(1) and Figure 8.22.2.1.2.

8.22.2.1.4.2 Fire-exposed side.

Where gypsum wallboard or plaster is applied to the fire-exposed side of the wall, the contribution of the finish to the total fire-resistance rating shall be determined as follows: The time assigned to the finish as established by Table 8.22.2.1.4(2) shall be added to the fire-resistance rating determined from Tables 8.22.2.1.1 and 8.22.2.1.2(1) and Figure 8.22.2.1.2 for the concrete alone, or to the rating determined in Clause 8.22.2.1.4.1 for the concrete and finish on the nonfire-exposed side.

8.22.2.1.4.3 Nonsymmetrical assemblies.

For a wall without finish on one side or having different types or thicknesses of finish on each side, the calculation procedures of Clauses 8.22.2.1.4.1 and 8.22.2.1.4.2 shall be performed twice, assuming either side of the wall to be the fire-exposed side. The fire-resistance rating of the wall shall not exceed the lower of the two values.

Exception: For an exterior wall with a fire separation distance greater than 1524 mm (5 feet) the fire shall be assumed to occur on the interior side only.

8.22.2.1.4.4 Minimum concrete fire-resistance rating.

Where finishes applied to one or both sides of a concrete wall contribute to the fire-resistance rating, the concrete alone shall provide not less than one-half of the total required fire-resistance rating. Additionally, the contribution to the fire resistance of the finish on the nonfire-exposed side of a load-bearing wall shall not exceed one-half the contribution of the concrete alone.

8.22.2.1.4.5 Concrete finishes.

Finishes on concrete walls that are assumed to contribute to the total fire-resistance rating of the wall shall comply with the installation requirements of Clause 8.22.3.2.5.

8.22.2.2 Concrete floor and roof slabs.

Reinforced and prestressed floors and roofs shall comply with Clause 8.22.2.2.1. Multicourse floors and roofs shall comply with Clauses 8.22.2.2.2 and 8.22.2.2.3, respectively.

8.22.2.2.1 Reinforced and prestressed floors and roofs.

The minimum thicknesses of reinforced and prestressed concrete floor or roof slabs for fire-resistance ratings of 1 hour to 4 hours are shown in Table 8.22.2.2.1.

Exception: Minimum thickness shall not be required for floors and ramps within parking garages constructed in accordance with Clauses 4.6.5 and 4.6.6.

### TABLE 8.22.2.2.1

<table>
<thead>
<tr>
<th>CONCRETE TYPE</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Siliceous</td>
<td>3.5</td>
</tr>
<tr>
<td>Carbonate</td>
<td>3.2</td>
</tr>
<tr>
<td>Sand-lightweight</td>
<td>2.7</td>
</tr>
<tr>
<td>Lightweight</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

8.22.2.2.1.1 Hollow-core prestressed slabs.

For hollow-core prestressed concrete slabs in which the cores are of constant cross clause throughout the length, the equivalent thickness shall be permitted to be obtained by dividing the net cross-clauseal area of the slab including grout in the joints, by its width.

8.22.2.2.1.2 Slabs with sloping soffits.

The thickness of slabs with sloping soffits (see Figure 8.22.2.2.1.2) shall be determined at a distance 2t or 152 mm (6 inches), whichever is less, from the point of minimum thickness, where t is the minimum thickness.
Note: For SI: 1 inch = 25.4 mm

FIGURE 8.22.2.1.3 SLABS WITH RIBBED OR UNDULATING SOFFITS

8.22.2.2.2 Multicourse floors.

The fire-resistance ratings of floors that consist of a base slab of concrete with a topping (overlay) of a different type of concrete shall comply with Figure 8.22.2.2.2.

8.22.2.2.3 Multicourse roofs.

The fire-resistance ratings of roofs that consist of a base slab of concrete with a topping (overlay) of an insulating concrete or with an insulating board and built-up roofing shall comply with Figures 8.22.2.2.3(1) and 8.22.2.2.3(2).

Note: For: 1 inch = 25.4 mm

FIGURE 8.22.2.1.2 DETERMINATION OF SLAB THICKNESS FOR SLOPING SOFFITS

8.22.2.1.3 Slabs with ribbed soffits.

The thickness of slabs with ribbed or undulating soffits (see Figure 8.22.2.1.3) shall be determined by one of the following expressions, whichever is applicable:

For $s > 4t$, the thickness to be used shall be $t$

For $s \leq 2t$, the thickness to be used shall be $t_e$

For $4t > s > 2t$, the thickness to be used shall be

$$t + \left(\frac{4t}{s} - 1\right)(t_e - t)$$

(Equation 8-5)

Where:

$S$ = Spacing of ribs or undulations.

$T$ = Minimum thickness.

$t_e$ = Equivalent thickness of the slab calculated as the net area of the slab divided by the width, in which the maximum thickness used in the calculation shall not exceed $2t$. 

Note: For SI: 1 inch = 25.4 mm

FIGURE 8.22.2.2.1.3 SLABS WITH RIBBED OR UNDULATING SOFFITS
8.22.2.2.3.1 Heat transfer.

For the transfer of heat, three-ply built-up roofing contributes 10 minutes to the fire-resistance rating. The fire-resistance rating for concrete assemblies such as those shown in Figure 8.22.2.2.3(1) shall be increased by 10 minutes. This increase is not applicable to those shown in Figure 8.22.2.2.3(2).

8.22.2.2.4 Joints in precast slabs.

Joints between adjacent precast concrete slabs need not be considered in calculating the slab thickness provided that a concrete topping not less than 25 mm (1 inch) thick is used. Where concrete topping is not used, joints must be grouted to a depth of not less than one-third the slab thickness at the joint, but not less than 25 mm (1 inch), or the joints must be made fire resistant by other approved methods.

8.22.2.3 Concrete cover over reinforcement.

The minimum thickness of concrete cover over reinforcement in concrete slabs, reinforced beams and prestressed beams shall comply with this clause.
### TABLE 8.22.2.3(1)
COVER THICKNESS FOR REINFORCED CONCRETE FLOOR OR ROOF SLABS (inches)

<table>
<thead>
<tr>
<th>CONCRETE AGGREGATE TYPE</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Restrained</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td></td>
<td>Unrestrained</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>Siliceous</td>
<td></td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>1</td>
</tr>
<tr>
<td>Carbonate</td>
<td></td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>1</td>
</tr>
<tr>
<td>Sand-lightweight or lightweight</td>
<td></td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: SI inch = 25.4 mm.

### TABLE 8.22.2.3(2)
COVER THICKNESS FOR PRESTRESSED CONCRETE FLOOR OR ROOF SLABS (inches)

<table>
<thead>
<tr>
<th>CONCRETE AGGREGATE TYPE</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Restrained</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td></td>
<td>Unrestrained</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>Siliceous</td>
<td></td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>1</td>
</tr>
<tr>
<td>Carbonate</td>
<td></td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>1</td>
</tr>
<tr>
<td>Sand-lightweight or lightweight</td>
<td></td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>3</td>
<td>3/4</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

### TABLE 8.22.2.3(3) MINIMUM COVER FOR MAIN REINFORCING BARS OF REINFORCED CONCRETE BEAMS (APPLICABLE TO ALL TYPES OF STRUCTURAL CONCRETE)

<table>
<thead>
<tr>
<th>TABLE 8.22.2.3(3)</th>
<th>TABLE 8.22.2.3(3)</th>
<th>TABLE 8.22.2.3(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINIMUM COVER FOR MAIN REINFORCING BARS OF REINFORCED CONCRETE BEAMS (APPLICABLE TO ALL TYPES OF STRUCTURAL CONCRETE)</td>
<td>MINIMUM COVER FOR MAIN REINFORCING BARS OF REINFORCED CONCRETE BEAMS (APPLICABLE TO ALL TYPES OF STRUCTURAL CONCRETE)</td>
<td>MINIMUM COVER FOR MAIN REINFORCING BARS OF REINFORCED CONCRETE BEAMS (APPLICABLE TO ALL TYPES OF STRUCTURAL CONCRETE)</td>
</tr>
<tr>
<td>1/2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
### TABLE 8.22.2.3(3)
**Minimum Cover for Main Reinforcing Bars of Reinforced Concrete Beams**

(Applicable to all types of structural concrete)

<table>
<thead>
<tr>
<th>Fire-Resistance Rating (hours)</th>
<th>1</th>
<th>1/2</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>1 4</td>
<td>3 4</td>
<td>3</td>
<td>3 4</td>
<td>3 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire-Resistance Rating (hours)</th>
<th>1</th>
<th>1/2</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 a</td>
<td>1 4</td>
<td>3 4</td>
<td>3</td>
<td>3 4</td>
<td>3 4</td>
</tr>
</tbody>
</table>

Note:

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Tabulated values for restrained assemblies apply to beams spaced more than 4 feet on center. For restrained beams spaced 4 feet or less on center, minimum cover of 3/4 inch is adequate for ratings of 4 hours or less.

b. For beam widths between the tabulated values, the minimum cover thickness can be determined by direct interpolation.

c. The cover for an individual reinforcing bar is the minimum thickness of concrete between the surface of the bar and the fire-exposed surface of the beam. For beams in which several bars are used, the cover for corner bars used in the calculation shall be reduced to one-half of the actual value. The cover for an individual bar must be not less than one-half of the value given in Table 8.22.2.3(3) nor less than 3/4 inch.

### TABLE 8.22.2.3(4)
**Minimum Cover for Prestressed Concrete Beams 8 Inches or Greater in Width**

<table>
<thead>
<tr>
<th>Restained or Unrestrained</th>
<th>Concrete Aggregate Type</th>
<th>Beam Width (Inches)</th>
<th>Fire-Resistance Rating (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1/2</td>
</tr>
<tr>
<td>Restained</td>
<td>Carbonate or siliceous</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Carbonate or siliceous</td>
<td>≥12</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sand lightweight</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sand lightweight</td>
<td>≥12</td>
<td>1</td>
</tr>
<tr>
<td>Unrestrained</td>
<td>Carbonate or siliceous</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Carbonate or siliceous</td>
<td>≥12</td>
<td>1</td>
</tr>
</tbody>
</table>

Note:

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Tabulated values for restrained assemblies apply to beams spaced more than 4 feet on center. For restrained beams spaced 4 feet or less on center, minimum cover of 3/4 inch is adequate for ratings of 4 hours or less.

b. For beam widths between the tabulated values, the minimum cover thickness can be determined by direct interpolation.

c. The cover for an individual reinforcing bar is the minimum thickness of concrete between the surface of the bar and the fire-exposed surface of the beam. For beams in which several bars are used, the cover for corner bars used in the calculation shall be reduced to one-half of the actual value. The cover for an individual bar must be not less than one-half of the value given in Table 8.22.2.3(3) nor less than 3/4 inch.

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Tabulated values for restrained assemblies apply to beams spaced more than 4 feet on center. For restrained beams spaced 4 feet or less on center, minimum cover of 3/4 inch is adequate for ratings of 4 hours or less.

b. For beam widths between the tabulated values, the minimum cover thickness can be determined by direct interpolation.

c. The cover for an individual reinforcing bar is the minimum thickness of concrete between the surface of the bar and the fire-exposed surface of the beam. For beams in which several bars are used, the cover for corner bars used in the calculation shall be reduced to one-half of the actual value. The cover for an individual bar must be not less than one-half of the value given in Table 8.22.2.3(3) nor less than 3/4 inch.
### 22.2.3(5) Minimum cover for prestressed concrete beams of all widths

<table>
<thead>
<tr>
<th>RESTRAINED OR UNRESTRAINED</th>
<th>CONCRETE AGGREGATE TYPE</th>
<th>BEAM AREA A (square inches)</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>40 ≤ A ≥ 150</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Carbonate or siliceous</td>
<td>150 &lt; A ≤ 300</td>
<td>1/2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 &lt; A</td>
<td>1 1/2</td>
</tr>
<tr>
<td></td>
<td>Sand lightweight</td>
<td>150 &lt; A</td>
<td>1 1/2</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>40 ≥ A ≤ 150</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Carbonate or siliceous</td>
<td>150 &lt; A ≤ 300</td>
<td>1 1/2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 &lt; A</td>
<td>1 1/2</td>
</tr>
<tr>
<td></td>
<td>Sand lightweight</td>
<td>150 &lt; A</td>
<td>1 1/2</td>
</tr>
</tbody>
</table>

**Note**: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square inch = 645.2 mm².

a. Tabulated values for restrained assemblies apply to beams spaced more than 4 feet on center. For restrained beams spaced 4 feet or less on center, minimum cover of 3/4 inch is adequate for 4-hour ratings or less.

b. For beam widths between 8 inches and 12 inches, minimum cover thickness can be determined by direct interpolation.

c. Not practical for 8-inch-wide beam but shown for purposes of interpolation.

### 8.22.2.3.1 Slab cover.

The minimum thickness of concrete cover to the positive moment reinforcement shall comply with Table 8.22.2.3(1) for reinforced concrete and Table 8.22.2.3(2) for prestressed concrete. These tables are applicable for solid or hollow-core one-way or two-way slabs with flat undersurfaces. These tables are applicable to slabs that are either cast in place or precast. For precast prestressed concrete not covered elsewhere, the procedures contained in this Code shall be acceptable.

### 8.22.2.3.2 Reinforced beam cover.

The minimum thickness of concrete cover to the positive moment reinforcement (bottom steel) for reinforced concrete beams is shown in Table 8.22.2.3(3) for fire-resistance ratings of 1 hour to 4 hours.

### 8.22.2.3.3 Prestressed beam cover.

The minimum thickness of concrete cover to the positive moment prestressing tendons (bottom steel) for restrained and unrestrained prestressed concrete beams and stemmed units shall comply with the values shown in Tables 8.22.2.3(4) and 8.22.2.3(5) for fire-
resistance ratings of 1 hour to 4 hours. Values in Table 8.22.2.3(4) apply to beams 8 inches (203 mm) or greater in width. Values in Table 8.22.2.3(5) apply to beams or stems of any width, provided that the cross- clause area is not less than 40 square inches (25806 mm²). In case of differences between the values determined from Table 8.22.2.3(4) or 8.22.2.3(5), it is permitted to use the smaller value. The concrete cover shall be calculated in accordance with Clause 8.22.2.3.3.1. The minimum concrete cover for non prestressed reinforcement in prestressed concrete beams shall comply with Clause 8.22.2.3.2.

8.22.2.3.3.1 Calculating concrete cover.

The concrete cover for an individual tendon is the minimum thickness of concrete between the surface of the tendon and the fire-exposed surface of the beam, except that for ungrouted ducts, the assumed cover thickness is the minimum thickness of concrete between the surface of the duct and the fire-exposed surface of the beam. For beams in which two or more tendons are used, the cover is assumed to be the average of the minimum cover of the individual tendons. For corner tendons (tendons equal distance from the bottom and side), the minimum cover used in the calculation shall be one-half the actual value. For stemmed members with two or more prestressing tendons located along the vertical centerline of the stem, the average cover shall be the distance from the bottom of the member to the centroid of the tendons. The actual cover for any individual tendon shall be not less than one-half the smaller value shown in Tables 8.22.2.3(4) and 8.22.2.3(5), or 1 inch (25 mm), whichever is greater.

8.22.2.4 Concrete columns.

Concrete columns shall comply with this clause.

**TABLE 8.22.2.4 MINIMUM DIMENSION OF CONCRETE COLUMNS (inches)**

<table>
<thead>
<tr>
<th>TYPES OF CONCRETE</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
<th>1</th>
<th>1/2</th>
<th>a</th>
<th>3</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siliceous</td>
<td></td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Carbonate</td>
<td></td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25 mm.

- a. The minimum dimension is permitted to be reduced to 8 inches for rectangular columns with two parallel sides not less than 36 inches in length.
- b. The minimum dimension is permitted to be reduced to 10 inches for rectangular columns with two parallel sides not less than 36 inches in length.

**8.22.2.4.1 Minimum size.**

The minimum overall dimensions of reinforced concrete columns for fire-resistance ratings of 1 hour to 4 hours for exposure to fire on all sides shall comply with this clause.

8.22.2.4.1.1 Concrete strength less than or equal to 12,000 psi.

For columns made with concrete having a specified compressive strength, $f'_{c}$, of less than or equal to 12,000 psi (82.7 MPa), the minimum dimension shall comply with Table 8.22.2.4.

8.22.2.4.1.2 Concrete strength greater than 12,000 psi.

For columns made with concrete having a specified compressive strength, $f'_{c}$, greater than 12,000 psi (82.7 MPa), for fire-resistance ratings of 1 hour to 4 hours the minimum dimension shall be 610 mm (24 inches).

8.22.2.4.2 Minimum cover for R/C columns.

The minimum thickness of concrete cover to the main longitudinal reinforcement in columns, regardless of the type of aggregate used in the concrete and the specified compressive strength of concrete, $f'_{c}$, shall be not less than 25 mm (1 inch) times the number of hours of required fire resistance or 51 mm (2 inches), whichever is less.

8.22.2.4.3 Tie and spiral reinforcement.

For concrete columns made with concrete having a specified compressive strength, $f'_{c}$, greater than 82.7 MPa (12,000 psi), tie and spiral reinforcement shall comply with the following:

1. The free ends of rectangular ties shall terminate with a 135-degree (2.4 rad) standard tie hook.
2. The free ends of circular ties shall terminate with a 90-degree (1.6 rad) standard tie hook.

3. The free ends of spirals, including at lap splices, shall terminate with a 90-degree (1.6 rad) standard tie hook.

The hook extension at the free end of ties and spirals shall be the larger of six bar diameters and the extension required by this Code. Hooks shall project into the core of the column.

8.22.2.4 Columns built into walls.

The minimum dimensions of Table 8.22.2.4 do not apply to a reinforced concrete column that is built into a concrete or masonry wall provided that all of the following are met:

1. The fire-resistance rating for the wall is equal to or greater than the required rating of the column.
2. The main longitudinal reinforcing in the column has cover not less than that required by Clause 8.22.2.4.2.
3. Openings in the wall are protected in accordance with Clause 8.16.

Where openings in the wall are not protected as required by Clause 8.16, the minimum dimension of columns required to have a fire-resistance rating of 3 hours or less shall be 203 mm (8 inches), and 254 mm (10 inches) for columns required to have a fire-resistance rating of 4 hours, regardless of the type of aggregate used in the concrete.

8.22.2.4.5 Precast cover units for steel columns.

See Clause 8.22.5.1.4.

8.22.3 Concrete masonry.

The provisions of this clause contain procedures by which the fire-resistance ratings of concrete masonry are established by calculations.

8.22.3.1 Equivalent thickness.

The equivalent thickness of concrete masonry construction shall be determined in accordance with the provisions of this clause.

8.22.3.1.1 Concrete masonry unit plus finishes.

The equivalent thickness of concrete masonry assemblies, \( T_{ea} \), shall be computed as the sum of the equivalent thickness of the concrete masonry unit, \( T_e \), as determined by Clause 8.22.3.1.2, 8.22.3.1.3 or 8.22.3.1.4, plus the equivalent thickness of finishes, \( T_{ef} \), determined in accordance with Clause 8.22.3.2:

\[
T_{ea} = T_e + T_{ef} \quad \text{(Equation 8-6)}
\]

8.22.3.1.2 Ungroated or partially grouted construction.

\( T_e \) shall be the value obtained for the concrete masonry unit determined in accordance with ASTM C140.

8.22.3.1.3 Solid grouted construction.

The equivalent thickness, \( T_e \), of solid grouted concrete masonry units is the actual thickness of the unit.

8.22.3.1.4 Airspaces and cells filled with loose-fill material.

The equivalent thickness of completely filled hollow concrete masonry is the actual thickness of the unit where loose-fill materials are: sand, pea gravel, crushed stone, or slag that meet ASTM C33 requirements; pumice, scoria, expanded shale, expanded clay, expanded slate, expanded slag, expanded fly ash, or cinders that comply with ASTM C331; or perlite or vermiculite meeting the requirements of ASTM C549 and ASTM C516, respectively.

8.22.3.2 Concrete masonry walls.

The fire-resistance rating of walls and partitions constructed of concrete masonry units shall be determined from Table 8.22.3.2. The rating shall be based on the equivalent thickness of the masonry and type of aggregate used.
TABLE 8.22.3.2 MINIMUM EQUIVALENT THICKNESS (inches) OF BEARING OR NONBEARING CONCRETE MASONRY WALLS\textsuperscript{a, b, c, d}

<table>
<thead>
<tr>
<th>TYPE OF AGGREGATE</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumice or expanded slag</td>
<td>1.5</td>
</tr>
<tr>
<td>Expanded shale, clay or slate</td>
<td>1.8</td>
</tr>
<tr>
<td>Limestone, cinders or unexpanded slag</td>
<td>1.9</td>
</tr>
<tr>
<td>Calcareous or siliceous gravel</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Note: For SI: $1$ inch $= 25.4$ mm.
\textsuperscript{a} Values between those shown in the table can be determined by direct interpolation.
\textsuperscript{b} Where combustible members are framed into the wall, the thickness of solid material between the end of each member and the opposite face of the wall, or between members set in from opposite sides, shall be not less than 93 percent of the thickness shown in the table.
\textsuperscript{c} Requirements of ASTM C55, ASTM C73, ASTM C90 or ASTM C744 shall apply.
\textsuperscript{d} Minimum required equivalent thickness corresponding to the hourly fire-resistance rating for units with a combination of aggregate shall be determined by linear interpolation based on the percent by volume of each aggregate used in manufacture.

8.22.3.2.1 Finish on nonfire-exposed side.

Where plaster or gypsum wallboard is applied to the side of the wall not exposed to fire, the contribution of the finish to the total fire-resistance rating shall be determined as follows: The thickness of gypsum wallboard or plaster shall be corrected by multiplying the actual thickness of the finish by applicable factor determined from Table 8.22.2.1.4(1). This corrected thickness of finish shall be added to the equivalent thickness of masonry and the fire-resistance rating of the masonry and finish determined from Table 8.22.3.2.

8.22.3.2.2 Finish on fire-exposed side.

Where plaster or gypsum wallboard is applied to the fire-exposed side of the wall, the contribution of the finish to the total fire-resistance rating shall be determined as follows: The time assigned to the finish as established by Table 8.22.2.1.4(2) shall be added to the fire-resistance rating determined in Clause 8.22.3.2 for the masonry alone, or in Clause 8.22.3.2.1 for the masonry and finish on the nonfire-exposed side.

8.22.3.2.3 Nonsymmetrical assemblies.

For a wall without finish on one side or having different types or thicknesses of finish on each side, the calculation procedures of this clause shall be performed twice, assuming either side of the wall to be the fire-exposed side. The fire-resistance rating of the wall shall not exceed the lower of the two values calculated.

Exception: For exterior walls with a fire separation distance greater than 1524 mm (5 feet), the fire shall be assumed to occur on the interior side only.

8.22.3.2.4 Minimum concrete masonry fire-resistance rating.

Where the finish applied to a concrete masonry wall contributes to its fire-resistance rating, the masonry alone shall provide not less than one-half the total required fire-resistance rating.

8.22.3.2.5 Attachment of finishes.

Installation of finishes shall be as follows:

1. Gypsum wallboard and gypsum lath applied to concrete masonry or concrete walls shall be secured to wood or steel furring members spaced not more than 406 mm (16 inches) on center (o.c.).
2. Gypsum wallboard shall be installed with the long dimension parallel to the furring members and shall have all joints finished.

3. Other aspects of the installation of finishes shall comply with the applicable provisions of Parts 8 and 26.

8.22.3.3 Multiwythe masonry walls.

The fire-resistance rating of wall assemblies constructed of multiple wythes of masonry materials shall be permitted to be based on the fire-resistance rating period of each wythe and the continuous airspace between each wythe in accordance with the following formula:

\[ R_A = (R_1^{0.60} + R_2^{0.60} + \ldots + R_n^{0.60} + A_1 + A_2 + \ldots + A_n)^{1.7} \]

Where:
- \( R_A \) = Fire-resistance rating of the assembly (hours).
- \( R_1, R_2, \ldots, R_n \) = Fire-resistance rating of wythes for 1, 2, n (hours), respectively.
- \( A_1, A_2, \ldots, A_n \) = 0.30, factor for each continuous airspace for 1, 2, ..,n, respectively, having a depth of 1/2 inch (12.7 mm) or more between wythes.

8.22.3.4 Concrete masonry lintels.

Fire-resistance ratings for concrete masonry lintels shall be determined based on the nominal thickness of the lintel and the minimum thickness of concrete masonry or concrete, or any combination thereof, covering the main reinforcing bars, as determined in accordance with Table 8.22.3.4, or by approved alternate methods.

**TABLE 8.22.3.4 MINIMUM COVER OF LONGITUDINAL REINFORCEMENT IN FIRE RESISTANCE-RATED REINFORCED CONCRETE MASONRY LINTELS (inches)**

<table>
<thead>
<tr>
<th>NOMINAL WIDTH OF LINTEL (inches)</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1/2</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1/2</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>1/4</td>
</tr>
<tr>
<td>10 or greater</td>
<td>1/2</td>
<td>1</td>
<td>1/2</td>
<td>1</td>
<td>3/4</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

8.22.3.5 Concrete masonry columns.

The fire-resistance rating of concrete masonry columns shall be determined based on the least plan dimension of the column in accordance with Table 8.22.3.5 or by approved alternate methods.

**TABLE 8.22.3.5 MINIMUM DIMENSION OF CONCRETE MASONRY COLUMNS (inches)**

<table>
<thead>
<tr>
<th>FIRE-RESISTANCE RATING (hours)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 inches</td>
<td>10 inches</td>
<td>12 inches</td>
<td>14 inches</td>
<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

8.22.4 Clay brick and tile masonry.

The provisions of this clause contain procedures by which the fire-resistance ratings of clay brick and tile masonry are established by calculations.

8.22.4.1 Masonry walls.

The fire-resistance rating of masonry walls shall be based on the equivalent thickness as calculated in accordance with this clause. The calculation shall take into account finishes applied to the wall and airspaces between wythes in multiwythe construction.

**TABLE 8.22.4.1(1) FIRE-RESISTANCE PERIODS OF CLAY MASONRY WALLS**

<table>
<thead>
<tr>
<th>MATERIAL TYPE</th>
<th>MINIMUM REQUIRED EQUIVALENT THICKNESS FOR FIRE RESISTANCE a, b, c (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid brick or clay or shale</td>
<td>2.7  3.8  4.9  6.0</td>
</tr>
<tr>
<td>Hollow brick or tile of clay or shale, unfilled</td>
<td>2.3  3.4  4.3  5.0</td>
</tr>
<tr>
<td>Hollow brick or tile of clay or shale, grouted or filled with materials specified in Clause</td>
<td>3.0  4.4  5.5  6.6</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.
722.4.1.1.3

**Note:** For SI: 1 inch = 25.4 mm.

a. Equivalent thickness as determined from Clause 8.22.4.1.1.
b. Calculated fire resistance between the hourly increments listed shall be determined by linear interpolation.
c. Where combustible members are framed in the wall, the thickness of solid material between the end of each member and the opposite face of the wall, or between members set in from opposite sides, shall be not less than 93 percent of the thickness shown.
d. For units in which the net cross-clausal area of cored brick in any plane parallel to the surface containing the cores is not less than 75 percent of the gross cross-clausal area measured in the same plane.

### TABLE 8.22.4.1(1)
FIRE-RESISTANCE PERIODS OF CLAY MASONRY WALLS

<table>
<thead>
<tr>
<th>WALL OR PARTITION ASSEMBLY</th>
<th>PLASTER SIDE EXPOSED (hours)</th>
<th>BRICK FACED SIDE EXPOSED (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside facing of steel studs: 1 / &quot; wood fiberboard 2 sheathing next to studs, 3 / &quot; airspace 4 formed with 3 / &quot; x 5 1 / &quot; wood strips 8 placed over the fiberboard and secured to the studs; metal or wire lath nailed to such strips, 3 / &quot; brick veneer 4 held in place by filling 3 / &quot; airspace 4 between the brick and lath with mortar. Inside facing of studs: 1 / &quot; unsanded gypsum plaster on metal or wire lath attached to 5 / &quot; 16 &quot; wood strips secured to edges of the studs.</td>
<td>1.5</td>
<td>4</td>
</tr>
<tr>
<td>Outside facing of steel studs: 1&quot; insulation board sheathing attached to studs, 1&quot; airspace, 3 and 3 / 4 &quot; brick veneer attached to steel frame with metal ties every 5th course. Inside facing of studs: 1 / &quot; sanded gypsum plaster (1:2 mix) applied on metal or wire lath attached directly to the studs.</td>
<td>1.5</td>
<td>4</td>
</tr>
<tr>
<td>Outside facing of steel studs: 1 / &quot; insulation board sheathing attached to studs, 1&quot; airspace, 3 and 3 / 4 &quot; brick veneer attached to steel frame with metal ties every 5th course. Inside facing of studs: 1 / &quot; sanded gypsum plaster (1:2 mix) applied to metal or wire.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Outside facing of steel studs: 1 / 2 &quot; gypsum sheathing board, attached to studs, 3 / 4 &quot; brick veneer attached to steel frame with metal ties every 5th course. Inside facing of studs: 1 / 2 &quot; sanded gypsum plaster (1:2 mix) 1 applied to 1 / 2 &quot; perforated gypsum lath securely attached to studs and having strips of metal lath 3 inches wide applied to all horizontal joints of gypsum lath.</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm.
TABLE 8.22.4.1(3)
VALUES OF $R_n^{0.59}$

<table>
<thead>
<tr>
<th>$R_n$</th>
<th>$R$ (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>1.50</td>
</tr>
<tr>
<td>3</td>
<td>1.91</td>
</tr>
<tr>
<td>4</td>
<td>2.27</td>
</tr>
</tbody>
</table>

TABLE 8.22.4.1(4)
COEFFICIENTS FOR PLASTER, $p$\textsuperscript{a}

<table>
<thead>
<tr>
<th>THICKNESS OF PLASTER (inch)</th>
<th>ONE SIDE</th>
<th>TWO SIDES</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>$\frac{5}{8}$</td>
<td>0.37</td>
<td>0.75</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>0.45</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.
\textsuperscript{a} Values listed in the table are for 1:3 sanded gypsum plaster.

TABLE 8.22.4.1(5)
REINFORCED MASONRY LINTELS

<table>
<thead>
<tr>
<th>NOMINAL LINTEL WIDTH (inches)</th>
<th>MINIMUM LONGITUDINAL REINFORCEMENT COVER FOR FIRE RESISTANCE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td>6</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>8</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>10 or more</td>
<td>$\frac{1}{2}$</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.
NP = Not Permitted.

TABLE 8.22.4.1(6) REINFORCED CLAY MASONRY COLUMNS

<table>
<thead>
<tr>
<th>COLUMN SIZE</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Minimum column dimension (inches)</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

8.22.4.1.1 Equivalent thickness.

The fire-resistance ratings of walls or partitions constructed of solid or hollow clay masonry units shall be determined from Table 8.22.4.1(1) or 8.22.4.1(2). The equivalent thickness of the clay masonry unit shall be determined by Equation 7-8 where using Table 8.22.4.1(1). The fire-resistance rating determined from Table 8.22.4.1(1) shall be permitted to be used in the calculated fire-resistance rating procedure in Clause 8.22.4.2.

$$T_e = \text{The equivalent thickness of the clay masonry unit (inches).}$$

$$V_n = \text{The net volume of the clay masonry unit (inch}^3).$$

$$L = \text{The specified length of the clay masonry unit (inches).}$$

$$H = \text{The specified height of the clay masonry unit (inches).}$$

8.22.4.1.1.1 Hollow clay units.

The equivalent thickness, $T_e$, shall be the value obtained for hollow clay units as determined in accordance with Equation 7-8. The net volume, $V_n$, of the units shall be determined using the gross volume and percentage of void area determined in accordance with ASTM C67.

8.22.4.1.1.2 Solid grouted clay units.

The equivalent thickness of solid grouted clay masonry units shall be taken as the actual thickness of the units.

8.22.4.1.1.3 Units with filled cores.

The equivalent thickness of the hollow clay masonry units is the actual thickness of the unit where completely filled with loose-fill materials of: sand, pea gravel, crushed stone, or slag that meet ASTM C33 requirements; pumice, scoria, expanded shale, expanded clay, expanded slate, expanded slag, expanded fly ash, or cinders in compliance with ASTM C331; or perlite or vermiculite meeting the requirements of ASTM C549 and ASTM C516, respectively.

8.22.4.1.2 Plaster finishes.

Where plaster is applied to the wall, the total fire-resistance rating shall be determined by the formula:

$$R = (R_n^{0.59} + pl)^{1.7}$$

(Equation 8-9)
where:

\[ R = \text{The fire-resistance rating of the assembly (hours).} \]

\[ R_n = \text{The fire-resistance rating of the individual wall (hours).} \]

\[ p_l = \text{Coefficient for thickness of plaster.} \]

Values for \( R_n^{0.59} \) for use in Equation 8-9 are given in Table 8.22.4.1(3). Coefficients for thickness of plaster shall be selected from Table 8.22.4.1(4) based on the actual thickness of plaster applied to the wall or partition and whether one or two sides of the wall are plastered.

8.22.4.1.3 Multiwythe walls with airspace.
Where a continuous airspace separates multiple wythes of the wall or partition, the total fire-resistance rating shall be determined by the formula:

\[
R = (R_1^{0.59} + R_2^{0.59} + \ldots + R_n^{0.59} + as)^{1.7} \tag{8-10}
\]

Where:

\[ R = \text{The fire-resistance rating of the assembly (hours).} \]

\[ R_1, R_2, \ldots, R_n = \text{The fire-resistance rating of the individual wythes (hours).} \]

\[ as = \text{Coefficient for continuous airspace.} \]

Values for \( R_n^{0.59} \) for use in Equation 7-10 are given in Table 8.22.4.1(3). The coefficient for each continuous airspace of 1/2 inch to 12.7 to 89 mm (31/2 inches) separating two individual wythes shall be 0.3.

8.22.4.1.4 Nonsymmetrical assemblies.
For a wall without finish on one side or having different types or thicknesses of finish on each side, the calculation procedures of this clause shall be performed twice, assuming either side to be the fire-exposed side of the wall. The fire resistance of the wall shall not exceed the lower of the two values determined.

Exception: For exterior walls with a fire separation distance greater than 1524 mm (5 feet), the fire shall be assumed to occur on the interior side only.

8.22.4.2 Multiwythe walls.
The fire-resistance rating for walls or partitions consisting of two or more dissimilar wythes shall be permitted to be determined by the formula:

\[
R = (R_1^{0.59} + R_2^{0.59} + \ldots + R_n^{0.59})^{1.7} \tag{8-11}
\]

Where:

\[ R = \text{The fire-resistance rating of the assembly (hours).} \]

\[ R_1, R_2, \ldots, R_n = \text{The fire-resistance rating of the individual wythes (hours).} \]

Values for \( R_n^{0.59} \) for use in Equation 8-11 are given in Table 8.22.4.1(3).

8.22.4.2.1 Multiwythe walls of different material.
For walls that consist of two or more wythes of different materials (concrete or concrete masonry units) in combination with clay masonry units, the fire-resistance rating of the different materials shall be determined based on the nominal width of the lintel and the minimum covering for the longitudinal reinforcement in accordance with Table 8.22.4.1(5).

8.22.4.3 Reinforced clay masonry lintels.
Fire-resistance ratings for clay masonry lintels shall be determined based on the nominal width of the lintel and the minimum covering for the longitudinal reinforcement in accordance with Table 8.22.4.1(5).

8.22.4.4 Reinforced clay masonry columns.
The fire-resistance ratings shall be determined based on the last plan dimension of the column in accordance with Table 8.22.4.1(6). The minimum cover for longitudinal reinforcement shall be 51 mm (2 inches).

8.22.4.5 Structural steel columns.
The provisions of this clause contain procedures by which the fire-resistance ratings of steel assemblies are established by calculations.

8.22.5 Steel assemblies.
The fire-resistance ratings of structural steel columns shall be based on the size of the
element and the type of protection provided in accordance with this clause.

minimum thickness galvanized or stainless steel shall be permitted to be erected with lap joints. The lap joints shall be permitted to be located anywhere around the perimeter of the column cover. The lap joints shall be secured with 1/2-inch-long No. 8 sheet metal screws spaced 12 inches on center. The column covers shall be provided with a minimum expansion clearance of 1/8 inch per linear foot between the ends of the cover and any restraining construction.

Note: For SI: 1 inch = 25.4 mm, 1 foot = 305 mm.
1. Structural steel column, either wide flange or tubular shapes.
2. Type X gypsum board or gypsum panel products in accordance with ASTM C1177, C1178, C1278, C1396 or C1658. The total thickness of gypsum board or gypsum panel products calculated as h in Clause 8.22.5.1.2 shall be applied vertically to an individual column using one of the following methods:
   1. As a single layer without horizontal joints.
   2. As multiple layers with horizontal joints not permitted in any layer.
   3. As multiple layers with horizontal joints staggered not less than 12 inches vertically between layers and not less than 8 feet vertically in any single layer. The total required thickness of gypsum board or gypsum panel products shall be determined on the basis of the specified fire-resistance rating and the weight-to-heated-perimeter ratio (W/D) of the column. For fire-resistance ratings of 2 hours or less, one of the required layers of gypsum board or gypsum panel product may be applied to the exterior of the sheet steel column covers with 1-inch long Type S screws spaced 1 inch from the wallboard edge and 8 inches on center. For such installations, 0.0149-inch minimum thickness galvanized or stainless steel shall be permitted to be erected with lap joints. The lap joints shall be permitted to be located anywhere around the perimeter of the column cover. The lap joints shall be secured with 1/2-inch-long No. 8 sheet metal screws spaced 12 inches on center. The column covers shall be provided with a minimum expansion clearance of 1/8 inch per linear foot between the ends of the cover and any restraining construction.
product to the steel studs and the third layer to the sheet metal angles at 24 inches on center. Type S screws 13/4 inches long shall be used for attaching the second layer of gypsum board or gypsum panel product to the steel studs and the fourth layer to the sheet metal angles at 12 inches on center. Type S screws 21/4 inches long shall be used for attaching the third layer of gypsum board or gypsum panel product to the steel studs at 12 inches on center.

For SI: 1 inch = 25.4 mm, 1 pound per linear foot/inch = 0.059 kg/m/mm.

**FIGURE 8.22.5.1(4) FIRE RESISTANCE OF STRUCTURAL STEEL COLUMNS PROTECTED WITH VARIOUS THICKNESSES OF TYPE X GYPSUM WALLBOARD**

a. The W/D ratios for typical wide flange columns are listed in Table 8.22.5.1(1). For other column shapes, the W/D ratios shall be determined in accordance with Clause 8.22.5.1.1.

**FIGURE 8.22.5.1(5) WIDE FLANGE STRUCTURAL STEEL COLUMNS WITH SPRAYED FIRE-RESISTANT MATERIALS**

**FIGURE 8.22.5.1(6) CONCRETE PROTECTED STRUCTURAL STEEL COLUMNS**

Note: a. Where the inside perimeter of the concrete protection is not square, L shall be taken as the average of L1 and L2. Where the thickness of concrete cover is not constant, h shall be taken as the average of h1 and h2.

b. Joints shall be protected with not less than a 1-inch thickness of ceramic fiber blanket but in no case less than one-half the thickness of the column cover (see Clause 8.22.2.1.3).
CONCRETE OR CLAY MASONRY PROTECTED STRUCTURAL STEEL COLUMNS

Note: For SI: 1 inch = 25.4 mm.

\[ d = \text{Depth of a wide flange column, outside diameter of pipe column, or outside dimension of structural tubing column (inches).} \]

\[ t_{web} = \text{Thickness of web of wide flange column (inches).} \]

\[ w = \text{Width of flange of wide flange column (inches).} \]

TABLE 8.22.5.1(1) W/D RATIOS FOR STEEL COLUMNS

<table>
<thead>
<tr>
<th>STRUCTURAL SHAPE</th>
<th>CONTOUR PROFILE</th>
<th>BOX PROFILE</th>
<th>STRUCTURAL SHAPE</th>
<th>CONTOUR PROFILE</th>
<th>BOX PROFILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>W14 x 233</td>
<td>2.55</td>
<td>3.65</td>
<td>W10 x 112</td>
<td>1.81</td>
<td>2.57</td>
</tr>
<tr>
<td>x 211</td>
<td>2.32</td>
<td>3.35</td>
<td>x 100</td>
<td>1.64</td>
<td>2.33</td>
</tr>
<tr>
<td>x 193</td>
<td>2.14</td>
<td>3.09</td>
<td>x 88</td>
<td>1.45</td>
<td>2.08</td>
</tr>
<tr>
<td>x 176</td>
<td>1.96</td>
<td>2.85</td>
<td>x 77</td>
<td>1.28</td>
<td>1.85</td>
</tr>
<tr>
<td>x 159</td>
<td>1.78</td>
<td>2.60</td>
<td>x 68</td>
<td>1.15</td>
<td>1.66</td>
</tr>
<tr>
<td>x 145</td>
<td>1.64</td>
<td>2.39</td>
<td>x 60</td>
<td>1.01</td>
<td>1.48</td>
</tr>
<tr>
<td>x 132</td>
<td>1.56</td>
<td>2.25</td>
<td>x 54</td>
<td>0.923</td>
<td>1.34</td>
</tr>
<tr>
<td>x 120</td>
<td>1.42</td>
<td>2.06</td>
<td>x 49</td>
<td>0.84</td>
<td>1.23</td>
</tr>
<tr>
<td>x 109</td>
<td>1.29</td>
<td>1.88</td>
<td>x 45</td>
<td>0.888</td>
<td>1.24</td>
</tr>
<tr>
<td>x 99</td>
<td>1.18</td>
<td>1.72</td>
<td>x 39</td>
<td>0.78</td>
<td>1.09</td>
</tr>
<tr>
<td>x 90</td>
<td>1.08</td>
<td>1.58</td>
<td>x 33</td>
<td>0.661</td>
<td>0.93</td>
</tr>
<tr>
<td>x 82</td>
<td>1.23</td>
<td>1.68</td>
<td>x 31</td>
<td>0.665</td>
<td>0.97</td>
</tr>
<tr>
<td>x 74</td>
<td>1.12</td>
<td>1.53</td>
<td>x 28</td>
<td>0.688</td>
<td>0.96</td>
</tr>
<tr>
<td>x 68</td>
<td>1.04</td>
<td>1.41</td>
<td>x 24</td>
<td>0.591</td>
<td>0.83</td>
</tr>
<tr>
<td>x 61</td>
<td>0.928</td>
<td>1.28</td>
<td>x 21</td>
<td>0.577</td>
<td>0.77</td>
</tr>
<tr>
<td>x 53</td>
<td>0.915</td>
<td>1.21</td>
<td>x 20</td>
<td>0.499</td>
<td>0.67</td>
</tr>
<tr>
<td>x 48</td>
<td>0.835</td>
<td>1.10</td>
<td>x 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x 43</td>
<td>0.752</td>
<td>0.99</td>
<td>x 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x 120</td>
<td>1.65</td>
<td>2.36</td>
<td>W6 x 25</td>
<td>0.696</td>
<td>1.00</td>
</tr>
<tr>
<td>x 106</td>
<td>1.47</td>
<td>2.11</td>
<td>x 20</td>
<td>0.563</td>
<td>0.82</td>
</tr>
<tr>
<td>x 96</td>
<td>1.34</td>
<td>1.93</td>
<td>x 16</td>
<td>0.584</td>
<td>0.78</td>
</tr>
<tr>
<td>x 87</td>
<td>1.22</td>
<td>1.76</td>
<td>x 15</td>
<td>0.431</td>
<td>0.63</td>
</tr>
<tr>
<td>x 79</td>
<td>1.11</td>
<td>1.61</td>
<td>x 12</td>
<td>0.448</td>
<td>0.60</td>
</tr>
<tr>
<td>x 72</td>
<td>1.02</td>
<td>1.48</td>
<td>x 9</td>
<td>0.338</td>
<td>0.46</td>
</tr>
<tr>
<td>x 65</td>
<td>0.925</td>
<td>1.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x 58</td>
<td>0.925</td>
<td>1.31</td>
<td>W5 x 19</td>
<td>0.644</td>
<td>0.93</td>
</tr>
<tr>
<td>x 53</td>
<td>0.855</td>
<td>1.20</td>
<td>x 16</td>
<td>0.55</td>
<td>0.80</td>
</tr>
<tr>
<td>x 50</td>
<td>0.909</td>
<td>1.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x 45</td>
<td>0.829</td>
<td>1.12</td>
<td>W4 x 13</td>
<td>0.556</td>
<td>0.79</td>
</tr>
<tr>
<td>x 40</td>
<td>0.734</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 pound per linear foot per inch = 0.059 kg/m/mm.
### TABLE 8.22.5.1(2) PROPERTIES OF CONCRETE

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>NORMAL-WEIGHT CONCRETE</th>
<th>STRUCTURAL LIGHTWEIGHT CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal conductivity (k&lt;sub&gt;c&lt;/sub&gt;)</td>
<td>0.95 Btu/hr · ft · °F</td>
<td>0.35 Btu/hr · ft · °F</td>
</tr>
<tr>
<td>Specific heat (c&lt;sub&gt;c&lt;/sub&gt;)</td>
<td>0.20 Btu/lb · °F</td>
<td>0.20 Btu/lb · °F</td>
</tr>
<tr>
<td>Density (P&lt;sub&gt;c&lt;/sub&gt;)</td>
<td>145 lb/ft&lt;sup&gt;3&lt;/sup&gt;</td>
<td>110 lb/ft&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Equilibrium (free) moisture content (m) by volume</td>
<td>4%</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 lb/ft<sup>3</sup> = 16.0185 kg/m<sup>3</sup>, Btu/hr · ft · °F = 1.731 W/(m · K).

### TABLE 8.22.5.1(3) THERMAL CONDUCTIVITY OF CONCRETE OR CLAY MASONRY UNITS

<table>
<thead>
<tr>
<th>DENSITY (d&lt;sub&gt;m&lt;/sub&gt;) OF UNITS (lb/ft&lt;sup&gt;3&lt;/sup&gt;)</th>
<th>THERMAL CONDUCTIVITY (K) OF UNITS (Btu/hr · ft · °F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Masonry Units</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>0.207</td>
</tr>
<tr>
<td>85</td>
<td>0.228</td>
</tr>
<tr>
<td>90</td>
<td>0.252</td>
</tr>
<tr>
<td>95</td>
<td>0.278</td>
</tr>
<tr>
<td>100</td>
<td>0.308</td>
</tr>
<tr>
<td>105</td>
<td>0.340</td>
</tr>
<tr>
<td>110</td>
<td>0.376</td>
</tr>
<tr>
<td>115</td>
<td>0.416</td>
</tr>
<tr>
<td>120</td>
<td>0.459</td>
</tr>
<tr>
<td>125</td>
<td>0.508</td>
</tr>
<tr>
<td>130</td>
<td>0.561</td>
</tr>
<tr>
<td>135</td>
<td>0.620</td>
</tr>
<tr>
<td>140</td>
<td>0.685</td>
</tr>
<tr>
<td>145</td>
<td>0.758</td>
</tr>
<tr>
<td>150</td>
<td>0.837</td>
</tr>
<tr>
<td>Clay Masonry Units</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>1.25</td>
</tr>
<tr>
<td>130</td>
<td>2.25</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 pound per cubic foot = 16.0185 kg/m<sup>3</sup>, Btu/hr · ft · °F = 1.731 W/(m · K).

### TABLE 8.22.5.1(4) WEIGHT-TO-HEATED-PERIMETER RATIOS (W/D) FOR TYPICAL WIDE FLANGE BEAM AND GIRDER SHAPES

<table>
<thead>
<tr>
<th>STRUCTURAL SHAPE</th>
<th>CONTOUR PROFILE</th>
<th>BOX PROFILE</th>
<th>STRUCTURAL SHAPE</th>
<th>CONTOUR PROFILE</th>
<th>BOX PROFILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>W36 x 300</td>
<td>2.50</td>
<td>3.33</td>
<td>W24 x 68</td>
<td>0.942</td>
<td>1.21</td>
</tr>
<tr>
<td>x 280</td>
<td>2.35</td>
<td>3.12</td>
<td>x 62</td>
<td>0.934</td>
<td>1.14</td>
</tr>
<tr>
<td>x 260</td>
<td>2.18</td>
<td>2.92</td>
<td>x 35</td>
<td>0.828</td>
<td>1.02</td>
</tr>
<tr>
<td>x 245</td>
<td>2.08</td>
<td>2.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x 230</td>
<td>1.95</td>
<td>2.61</td>
<td>W21 x 147</td>
<td>1.87</td>
<td>2.60</td>
</tr>
<tr>
<td>x 210</td>
<td>1.96</td>
<td>2.45</td>
<td>x 132</td>
<td>1.68</td>
<td>2.35</td>
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308
### TABLE 8.22.5.1(4)—continued

**WEIGHT-TO-HEATED-PERIMETER RATIOS (W/D) FOR TYPICAL WIDE FLANGE BEAM AND GIRDER SHAPES**

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(Continued)
### TABLE 8.22.5.1(4)—continued
**WEIGHT-TO-HEATED-PERIMETER RATIOS (W/D) FOR TYPICAL WIDE FLANGE BEAM AND GIRDER SHAPES**

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**Note:** For SI: 1 pound per linear foot per inch = 0.059 kg/m/mm.
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<th>MINIMUM REQUIRED EQUIVALENT THICKNESS (INCHES)</th>
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<th>MINIMUM REQUIRED EQUIVALENT THICKNESS (INCHES)</th>
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<td>110  1.42  2.50  3.37  4.14</td>
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<td>120  1.48  2.59  3.49  4.28</td>
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4 × 4 × 1/2 in wall thickness

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<th>MINIMUM REQUIRED EQUIVALENT THICKNESS (INCHES)</th>
<th>COLUMN SIZE</th>
<th>CONCRETE MASONRY DENSITY (POUNDS PER CUBIC FOOT)</th>
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<td>100  0.95  1.99  2.85  3.62</td>
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<th>MINIMUM REQUIRED EQUIVALENT THICKNESS FOR FIRE-RESISTANCE RATING OF CONCRETE MASONRY PROTECTION ASSEMBLY, T_e (inches)</th>
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<td>2.48</td>
<td>3.38</td>
<td>4.17</td>
<td>120</td>
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Note: For SI: 1 inch = 25.4 mm, 1 pound per cubic foot = 16.02 kg/m³.
Note: Tabulated values assume 1-inch air gap between masonry and steel clause.
### Table 8.22.5.1(6)

#### Fire Resistance of Clay Masonry Protected Steel Columns

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<thead>
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<tbody>
<tr>
<td><strong>4 x 4 x ⅝ wall thickness</strong></td>
<td>120 1.44 2.72 3.76 4.68</td>
<td>4 double extra strong 0.674 wall thickness</td>
<td>120 1.26 2.55 3.60 4.52</td>
<td>130 1.62 2.90 3.96 4.89</td>
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<td>130 1.62 3.00 4.12 5.11</td>
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<tr>
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<td>4 extra strong 0.375 wall thickness</td>
<td>120 1.60 2.89 3.92 4.83</td>
<td>130 1.84 3.18 4.28 5.15</td>
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<td>5 double extra strong 0.750 wall thickness</td>
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<td>130 1.33 2.72 3.78 4.76</td>
<td>130 1.55 2.82 3.85 4.76</td>
<td>5 strong 0.750 wall thickness</td>
</tr>
<tr>
<td><strong>6 x 6 x ¾ wall thickness</strong></td>
<td>120 1.48 2.74 3.76 4.67</td>
<td>5 extra strong 0.375 wall thickness</td>
<td>120 1.55 2.82 3.85 4.76</td>
<td>130 1.72 3.09 4.21 5.18</td>
<td>5 extra strong 0.375 wall thickness</td>
</tr>
<tr>
<td></td>
<td>130 1.65 3.01 4.13 5.10</td>
<td>5 standard 0.288 wall thickness</td>
<td>130 1.72 3.09 4.21 5.18</td>
<td>130 1.88 3.24 4.35 5.31</td>
<td>5 standard 0.288 wall thickness</td>
</tr>
<tr>
<td><strong>8 x 8 x ⅝ wall thickness</strong></td>
<td>120 1.27 2.50 3.52 4.42</td>
<td>6 double extra strong 0.864 wall thickness</td>
<td>120 1.04 2.28 3.32 4.23</td>
<td>130 1.19 2.60 3.68 4.67</td>
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<td>130 1.44 2.78 3.89 4.86</td>
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<td>130 1.65 2.99 4.10 5.08</td>
<td>6 strong 0.864 wall thickness</td>
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<td><strong>8 x 8 x ¾ wall thickness</strong></td>
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<td>6 extra strong 0.432 wall thickness</td>
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<td>130 1.82 3.19 4.30 5.27</td>
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Note: For SI: 1 inch = 25.4 mm, 1 pound per cubic foot = 16.02 kg/m³.
### TABLE 8.22.5.1(7) MINIMUM COVER (inch) FOR STEEL COLUMNS ENCASED IN NORMAL-WEIGHT CONCRETE\textsuperscript{a} [FIGURE 8.22.5.1(6)(c)]

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<td>× 132</td>
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<td>× 90</td>
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<tr>
<td>× 61</td>
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</tr>
<tr>
<td>× 48</td>
<td></td>
</tr>
<tr>
<td>× 43</td>
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</tr>
<tr>
<td>W12 × 152</td>
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<td>× 96</td>
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<td>× 50</td>
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</tr>
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<td>× 40</td>
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Note: For SI: 1 inch = 25.4 mm.

\textsuperscript{a}The tabulated thicknesses are based on the assumed properties of normal-weight concrete given in Table 722.5.1(2).

### TABLE 8.22.5.1(9) MINIMUM COVER (inch) FOR STEEL COLUMNS IN NORMAL WEIGHT PRECAST COVERS\textsuperscript{a} [FIGURE 8.22.5.1(6) (a)]
### TABLE 8.22.5.1(10) MINIMUM COVER (inch) FOR STEEL COLUMNS IN STRUCTURAL LIGHTWEIGHT PRECAST COVERS [FIGURE 722.5.1(6)(a)]

<table>
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</tr>
<tr>
<td>x 54</td>
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<td>3</td>
<td>4</td>
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</tr>
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<td>x 33</td>
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<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
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<td>3</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
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<td>3</td>
<td>4</td>
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<tr>
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<td>4</td>
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<td>4</td>
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<td>5</td>
<td>5</td>
<td>5</td>
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<td></td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm.

a. The tabulated thicknesses are based on the assumed properties of normal weight concrete given in Table 8.22.5.1(2).
### 8.22.5.1.1 General.

These procedures establish a basis for determining the fire resistance of column assemblies as a function of the thickness of fire-resistant material and, the weight, W, and heated perimeter, D, of structural steel columns. As used in these clauses, W is the average weight of a structural steel column in pounds per linear foot. The heated perimeter, D, is the inside perimeter of the fire-resistant material in inches as illustrated in Figure 8.22.5.1(1).

#### 8.22.5.1.1.1 Nonload-bearing protection.

The application of these procedures shall be limited to column assemblies in which the fire-resistant material is not designed to carry any of the load acting on the column.

#### 8.22.5.1.1.2 Embedments.

In the absence of substantiating fire-endurance test results, ducts, conduit, piping, and similar mechanical, electrical, and plumbing installations shall not be embedded in any required fire-resistant materials.

---

### Table: Fire-Resistance Rating (hours)

<table>
<thead>
<tr>
<th>Structural Shape</th>
<th>1</th>
<th>1/2</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>W14 × 233</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>2/2</td>
<td></td>
</tr>
<tr>
<td>× 176</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>× 145</td>
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<td>× 132</td>
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<td>× 109</td>
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<td>× 90</td>
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<td>× 68</td>
<td>2</td>
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<td></td>
<td></td>
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<tr>
<td>× 43</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W12 × 190</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>2/2</td>
<td></td>
</tr>
<tr>
<td>× 152</td>
<td></td>
<td></td>
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<td></td>
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<td>× 106</td>
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<td></td>
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<td>× 96</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>× 87</td>
<td>2</td>
<td>3/2</td>
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<td></td>
<td></td>
</tr>
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<td>× 65</td>
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<td>× 40</td>
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<td>W10 × 112</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>× 100</td>
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<td></td>
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<tr>
<td>× 88</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>× 77</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>× 60</td>
<td>2</td>
<td>3/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>× 39</td>
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<tr>
<td>× 33</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W8 × 67</td>
<td>1</td>
<td>1/2</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>× 48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>× 35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>× 28</td>
<td>2</td>
<td>3/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>× 18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W6 × 25</td>
<td>2</td>
<td>3</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>× 15</td>
<td>3</td>
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</tr>
<tr>
<td>× 9</td>
<td>3/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. The tabulated thicknesses are based on the assumed properties of structural lightweight concrete given in Table 8.22.5.1(2).
8.22.5.1.3 Weight-to-perimeter ratio.

Table 8.22.5.1(1) contains weight-to-heated-perimeter ratios (W/D) for both contour and box fire-resistant profiles, for the wide flange shapes most often used as columns. For different fire-resistant protection profiles or column cross clauses, the weight-to-heated-perimeter ratios (W/D) shall be determined in accordance with the definitions given in this clause.

8.22.5.1.2 Gypsum wallboard protection.

The fire resistance of structural steel columns with weight-to-heated-perimeter ratios (W/D) less than or equal to 3.65 and that are protected with Type X gypsum wallboard shall be permitted to be determined from the following expression:

\[ R = 130 \left[ \frac{h(W/D)}{2} \right]^{0.75} \]  
*(Equation 8-12)*

Where:
- \( R \) = Fire resistance (minutes).
- \( h \) = Total thickness of gypsum wallboard (inches).
- \( D \) = Heated perimeter of the structural steel column (inches).
- \( W' \) = Total weight of the structural steel column and gypsum wallboard protection (pounds per linear foot).
- \( W' = W + 50hD/144 \)

8.22.5.1.2.1 Attachment.

The gypsum board or gypsum panel products shall be supported as illustrated in either Figure 8.22.5.1(2) for fire-resistance ratings of 4 hours or less, or Figure 8.22.5.1(3) for fire-resistance ratings of 3 hours or less.

8.22.5.1.2.2 Gypsum wallboard equivalent to concrete.

The determination of the fire resistance of structural steel columns from Figure 8.22.5.1(4) is permitted for various thicknesses of gypsum wallboard as a function of the weight-to-heated-perimeter ratio (W/D) of the column. For structural steel columns with weight-to-heated-perimeter ratios (W/D) greater than 3.65, the thickness of gypsum wallboard required for specified fire-resistance ratings shall be the same as the thickness determined for a W14 x 233 wide flange shape.

8.22.5.1.3 Sprayed fire-resistant materials.

The fire resistance of wide-flange structural steel columns protected with sprayed fire-resistant materials, as illustrated in Figure 8.22.5.1(5), shall be permitted to be determined from the following expression:

\[ R = [C_1(W/D) + C_2]/h \]  
*(Equation 8-13)*

Where:
- \( R \) = Fire resistance (minutes).
- \( h \) = Thickness of sprayed fire-resistant material (inches).
- \( D \) = Heated perimeter of the structural steel column (inches).
- \( C_1 \) = Material-dependent constants.
- \( C_2 \) = 
- \( W' \) = Weight of structural steel columns (pounds per linear foot).

The fire resistance of structural steel columns protected with intumescent or mastic fire-resistant coatings shall be determined on the basis of fire-resistance tests in accordance with Clause 8.3.2.

8.22.5.1.3.1 Material-dependent constants.

The material-dependent constants, \( C_1 \) and \( C_2 \), shall be determined for specific fire-resistant materials on the basis of standard fire endurance tests in accordance with Clause 8.3.2. Unless evidence is submitted to the building official substantiating a broader application, this expression shall be limited to determining the fire resistance of structural steel columns with weight-to-heated-perimeter ratios (W/D) between the largest and smallest columns for which standard fire-resistance test results are available.

8.22.5.1.3.2 Identification.

Sprayed fire-resistant materials shall be identified by density and thickness required for a given fire-resistance rating.

8.22.5.1.4 Concrete-protected columns.

The fire resistance of structural steel columns protected with concrete, as illustrated in Figure 8.22.5.1(6)(a) and (b), shall be permitted to be determined from the following expression:

\[ R = R_c(1 + 0.03m) \]  
*(Equation 8-14)*
22.5.1(5) gives the thicknesses of concrete indicated in these tables apply to structural steel columns larger than those listed, with all reentrant spaces filled, Figure 8.22.5.1(6)(c).

As used in these expressions:

\[ R = \text{Fire endurance at equilibrium moisture conditions (minutes)} \]
\[ R_o = \text{Fire endurance at zero moisture content (minutes)} \]
\[ m = \text{Equilibrium moisture content of the concrete by volume (percent)} \]
\[ W = \text{Average weight of the structural steel column (pounds per foot)} \]
\[ D = \text{Heated perimeter of the structural steel column (inches)} \]
\[ h = \text{Thickness of the concrete cover (inches)} \]
\[ k = \text{Ambient temperature thermal conductivity of the concrete (Btu/hr ft °F)} \]
\[ c = \text{Ambient temperature specific heat of concrete (Btu/lb °F)} \]
\[ H = \text{Ambient temperature thermal capacity of the steel column (Btu/°F)} \]
\[ p_c = \text{Concrete density (pounds per cubic foot)} \]
\[ L = \text{Interior dimension of one side of a square concrete box protection (inches)} \]

8.22.5.1.4.1 Reentrant space filled.

For wide-flange structural steel columns completely encased in concrete with all reentrant spaces filled [Figure 8.22.5.1(6)(c)], the thermal capacity of the concrete within the reentrant spaces shall be permitted to be added to the thermal capacity of the steel column, as follows:

\[ H = 0.11 W + (p_c/144) (b_f d_A_s) \]  
(Equation 8-15)

Where:

\[ b_f = \text{Flange width of the structural steel column (inches)} \]
\[ d = \text{Depth of the structural steel column (inches)} \]
\[ A_s = \text{Cross-clausal area of the steel column (square inches)} \]

8.22.5.1.4.2 Concrete properties unknown.

If specific data on the properties of concrete are not available, the values given in Table 8.22.5.1(2) are permitted.

8.22.5.1.4.3 Minimum concrete cover.

For structural steel column encased in concrete with all reentrant spaces filled, Figure 8.22.5.1(6)(c) and Tables 8.22.5.1(7) and 8.22.5.1(8) indicate the thickness of concrete cover required for various fire-resistance ratings for typical wide-flange clauses. The equivalent thickness of concrete masonry protection (inches) [see Table 8.22.5.1(7)].

8.22.5.1.4.6 Equivalent concrete masonry thickness.

For structural steel columns protected with concrete masonry, Table 8.22.5.1(15) gives the equivalent thickness of concrete masonry...
required for various fire-resistance ratings for typical column shapes. For structural steel columns protected with clay masonry, Table 8.22.5.1(6) gives the equivalent thickness of concrete masonry required for various fire-resistance ratings for typical column shapes.

8.22.5.2 Structural steel beams and girders.

The fire-resistance ratings of structural steel beams and girders shall be based on the size of the element and the type of protection provided in accordance with this clause.

8.22.5.2.1 Determination of fire resistance.

These procedures establish a basis for determining resistance of structural steel beams and girders that differ in size from that specified in approved fire-resistance-rated assemblies as a function of the thickness of fire-resistant material and the weight (W) and heated perimeter (D) of the beam or girder. As used in these clauses, W is the average weight of a structural steel element in pounds per linear foot (plf). The heated perimeter, D, is the inside perimeter of the fire-resistant material in inches as illustrated in Figure 8.22.5.2.

8.22.5.2.1.1 Weight-to-heated perimeter.

The weight-to-heated-perimeter ratios (W/D), for both contour and box fire-resistant protection profiles, for the wide flange shapes most often used as beams or girders are given in Table 8.22.5.1(4). For different shapes, the weight-to-heated-perimeter ratios (W/D) shall be determined in accordance with the definitions given in this clause.

8.22.5.2.1.2 Beam and girder substitutions.

Except as provided for in Clause 8.22.5.2.2, structural steel beams in approved fire-resistance-rated assemblies shall be considered to be the minimum permissible size. Other beam or girder shapes shall be permitted to be substituted provided that the weight-to-heated-perimeter ratio (W/D) of the substitute beam is equal to or greater than that of the beam specified in the approved assembly.

8.22.5.2.2 Sprayed fire-resistant materials.

The provisions in this clause apply to structural steel beams and girders protected with sprayed fire-resistant materials. Larger or smaller beam and girder shapes shall be permitted to be substituted for beams specified in approved unrestrained or restrained fire-resistance-rated assemblies, provided that the thickness of the fire-resistant material is adjusted in accordance with the following expression:

\[
h_1 = h_2 \frac{[(W_2/D_2) + 0.60]}{[(W_1/D_1) + 0.60]}
\]

(Equation 8-17)

Where:

- \( h_1 \) = Thickness of sprayed fire-resistant material in inches.
- \( W \) = Weight of the structural steel beam or girder in pounds per linear foot.
- \( D \) = Heated perimeter of the structural steel beam or girder in inches.

Subscript 1 refers to the beam and fire-resistant material thickness in the approved assembly.

Subscript 2 refers to the substitute beam or girder and the required thickness of fire-resistant material.

The fire resistance of structural steel beams and girders protected with intumescent or mastic fire-resistant coatings shall be determined on the basis of fire-resistance tests in accordance with Clause 8.3.2.

8.22.5.2.2.1 Minimum thickness.

The use of Equation 8-17 is subject to the following conditions:

1. The weight-to-heated-perimeter ratio for the substitute beam or girder (W2/D2) shall be not less than 0.37.

2. The thickness of fire protection materials calculated for the substitute beam or girder (T1) shall be not less than 3/8 inch (9.5 mm).

3. The unrestrained or restrained beam rating shall be not less than 1 hour.

4. Where used to adjust the material thickness for a restrained beam, the use of this procedure is limited to structural steel clauses classified as compact in accordance with this Code.

8.22.5.2.3 Structural steel trusses.

The fire resistance of structural steel trusses protected with fire-resistant materials sprayed to each of the individual truss elements shall be permitted to be determined in accordance with this clause. The thickness of the fire-resistant material shall be determined in accordance with
Clause 8.22.5.1.3. The weight-to-heated-perimeter ratio (W/D) of truss elements that can be simultaneously exposed to fire on all sides shall be determined on the same basis as columns, as specified in Clause 8.22.5.1.1. The weight-to-heated-perimeter ratio (W/D) of truss elements that directly support floor or roof assembly shall be determined on the same basis as beams and girders, as specified in Clause 8.22.5.2.1.

The fire resistance of structural steel trusses protected with intumescent or mastic fire-resistant coatings shall be determined on the basis of fire-resistance tests in accordance with Clause 8.3.2.

8.22.6 Wood assemblies.

The provisions of this clause contain procedures by which the fire-resistance ratings of wood assemblies are established by calculations.

8.22.6.1 General.

This clause contains procedures for calculating the fire-resistance ratings of walls, floor/ceiling and roof/ceiling assemblies based in part on the standard method of testing referenced in Clause 8.3.2.

8.22.6.1.1 Maximum fire-resistance rating.

Fire-resistance ratings calculated for assemblies using the methods in Clause 8.22.6 shall be limited to not more than 1 hour.

8.22.6.1.2 Dissimilar membranes.

Where dissimilar membranes are used on a wall assembly that requires consideration of fire exposure from both sides, the calculation shall be made from the least fire-resistant (weaker) side.

8.22.6.2 Walls, floors and roofs.

These procedures apply to both load-bearing and nonload-bearing assemblies.

### TABLE 8.22.6.2(1)

<table>
<thead>
<tr>
<th>DESCRIPTION OF FINISH</th>
<th>TIME&lt;sup&gt;c&lt;/sup&gt; (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8-inch wood structural panel bonded with exterior glue</td>
<td>5</td>
</tr>
<tr>
<td>15/32-inch wood structural panel bonded with exterior glue</td>
<td>10</td>
</tr>
<tr>
<td>19/32-inch wood structural panel bonded with exterior glue</td>
<td>15</td>
</tr>
<tr>
<td>3/8-inch gypsum wallboard</td>
<td>10</td>
</tr>
<tr>
<td>1/2-inch gypsum wallboard</td>
<td>15</td>
</tr>
<tr>
<td>5/8-inch gypsum wallboard</td>
<td>30</td>
</tr>
<tr>
<td>1/2-inch Type X gypsum wallboard</td>
<td>25</td>
</tr>
<tr>
<td>5/8-inch Type X gypsum wallboard</td>
<td>40</td>
</tr>
<tr>
<td>Double 3/8-inch gypsum wallboard</td>
<td>25</td>
</tr>
<tr>
<td>1/2-inch + 3/8-inch gypsum wallboard</td>
<td>35</td>
</tr>
<tr>
<td>Double 1/2-inch gypsum wallboard</td>
<td>40</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. These values apply only where membranes are installed on framing members that are spaced 16 inches o.c. or less.

b. Gypsum wallboard installed over framing or furring shall be installed so that all edges are supported, except 5/8-inch Type X gypsum wallboard shall be permitted to be installed horizontally with the horizontal joints staggered 24 inches each side and unsupported but finished.

c. On wood frame floor/ceiling or roof/ceiling assemblies, gypsum board shall be installed with the long dimension perpendicular to framing members and shall have all joints finished.

d. The membrane on the unexposed side shall not be included in determining the fire resistance of the assembly. Where dissimilar membranes are used on a wall assembly, the calculation shall be made from the least fire-resistant (weaker) side.

e. The time assigned is not a finished rating.
### TABLE 8.22.6.2(3)
 MEMBRANE<sup>a</sup> ON EXTERIOR FACE OF WOOD STUD WALLS

<table>
<thead>
<tr>
<th>SHEATHING</th>
<th>PAPER</th>
<th>EXTERIOR FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8-inch T &amp; G timber</td>
<td></td>
<td>Timber siding</td>
</tr>
<tr>
<td>5/16-inch exterior glue wood</td>
<td>Sheathing paper</td>
<td>Wood shingles and shakes</td>
</tr>
<tr>
<td>structural panel</td>
<td></td>
<td>1/4-inch fiber-cement lap, panel or</td>
</tr>
<tr>
<td>1/2-inch gypsum wallboard</td>
<td></td>
<td>shingle siding</td>
</tr>
<tr>
<td>5/16-inch gypsum wallboard</td>
<td></td>
<td>1/4-inch wood structural panels</td>
</tr>
<tr>
<td>1/2-inch fiberboard</td>
<td></td>
<td>- exterior type</td>
</tr>
<tr>
<td>None</td>
<td>—</td>
<td>Metal siding</td>
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<tr>
<td></td>
<td></td>
<td>Stucco on metal lath</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Masonry veneer</td>
</tr>
<tr>
<td></td>
<td>3/8-inch exterior-grade wood</td>
<td>Vinyl siding</td>
</tr>
<tr>
<td>structural panels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. Any combination of sheathing, paper and exterior finish is permitted.

### TABLE 8.22.6.2(4)
 FLOORING OR ROOFING OVER WOOD FRAMING<sup>a</sup>

<table>
<thead>
<tr>
<th>ASSEMBLY</th>
<th>STRUCTURAL MEMBERS</th>
<th>SUBFLOOR OR ROOF DECK</th>
<th>FINISHED FLOORING OR ROOFING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td>Wood</td>
<td>15/32-inch wood structural panels or 11/16-inch T &amp; G softwood</td>
<td>Hardwood or softwood flooring on building paper resilient flooring, parquet floor felted-synthetic fiber floor coverings, carpeting, or ceramic tile on 1/4-inch-thick fiber-cement underlayment or 3/8-inch-thick panel-type underlay. Ceramic tile on 1/4-inch mortar bed.</td>
</tr>
<tr>
<td>Roof</td>
<td>Wood</td>
<td>15/32-inch wood structural panels or 11/16-inch T &amp; G softwood</td>
<td>Finished roofing material with or without insulation.</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

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a. This table does not apply to studs or joists spaced more than 16 inches o.c.
b. All studs shall be nominal 2 × 4 and all joists shall have a nominal thickness of not less than 2 inches.
c. Allowable spans for joists shall be determined in accordance with this Code.
Note: For SI: 1 inch = 25.4 mm.
a. This table applies only to wood joist construction. It is not applicable to wood truss construction.

### TABLE 8.22.6.2(5)
TIME ASSIGNED FOR ADDITIONAL PROTECTION

<table>
<thead>
<tr>
<th>DESCRIPTION OF ADDITIONAL PROTECTION</th>
<th>FIRE RESISTANCE (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add to the fire-resistance rating of wood stud walls if the spaces between the studs are completely filled with glass fiber mineral wool batts weighing not less than 2 pounds per cubic foot (0.6 pound per square foot of wall surface) or rockwool or slag material wool batts weighing not less than 3.3 pounds per cubic foot (1 pound per square foot of wall surface), or cellulose insulation having a nominal density not less than 2.6 pounds per cubic foot.</td>
<td>15</td>
</tr>
</tbody>
</table>

Note: For SI: 1 pound/cubic foot = 16.0185 kg/m3.

8.22.6.2.1 Fire-resistance rating of wood frame assemblies.

The fire-resistance rating of a wood frame assembly is equal to the sum of the time assigned to the membrane on the fire-exposed side, the time assigned to the framing members and the time assigned for additional contribution by other protective measures such as insulation. The membrane on the unexposed side shall not be included in determining the fire resistance of the assembly.

8.22.6.2.2 Time assigned to membranes.

Table 8.22.6.2(1) indicates the time assigned to membranes on the fire-exposed side.

8.22.6.2.3 Exterior walls.

For an exterior wall with a fire separation distance greater than 3048 mm (10 feet), the wall is assigned a rating dependent on the interior membrane and the framing as described in Tables 8.22.6.2(1) and 8.22.6.2(2). The membrane on the outside of the nonfire-exposed side of exterior walls with a fire separation distance greater than 3048 mm (10 feet) shall consist of sheathing, sheathing paper and siding as described in Table 8.22.6.2(3).

8.22.6.2.4 Floors and roofs.

In the case of a floor or roof, the standard test provides only for testing for fire exposure from below. Except as noted in Clause 8.3.3, Item 5, floor or roof assemblies of wood framing shall have an upper membrane consisting of a subfloor and finished floor conforming to Table 8.22.6.2(4) or any other membrane that has a contribution to fire resistance of not less than 15 minutes in Table 8.22.6.2(1).

8.22.6.2.5 Additional protection.

Table 8.22.6.2(5) indicates the time increments to be added to the fire resistance where glass fiber, rockwool, slag mineral wool or cellulose insulation is incorporated in the assembly.

8.22.6.2.6 Fastening.

Fastening of wood frame assemblies and the fastening of membranes to the wood framing members shall be done in accordance with Part 24.
PART 9: INTERIOR FINISHES

User notes:
About this part: Part 9 contains the performance requirements for controlling fire growth and smoke propagation within buildings by restricting interior finish and decorative materials. The provisions of this Part require materials used as interior finishes and decorations to meet certain flame spread index or flame propagation criteria and smoke development criteria based on the relative fire hazard associated with the occupancy. The performance of the material is evaluated based on test standards.

9.1 SCOPE

9.1.1 Scope.
The provisions of this Part shall govern the use of materials used as interior finishes, trim and decorative materials. The requirements for wall and ceiling finishes in this clause are basic requirements. Where a wall or ceiling assembly is required to provide a certain fire-resistance, a flame-spread rating or a sound transmission class rating, the wall or ceiling finishing shall be subject to the appropriate requirements in part 3 in addition to requirements in this Clause.

9.2 GENERAL

9.2.1 Interior wall and ceiling finish.
The provisions of Clause 9.3 shall limit the allowable fire performance and smoke development of interior wall and ceiling finish materials based on occupancy classification.

9.2.2 Interior floor finish.
The provisions of Clause 9.4 shall limit the allowable fire performance of interior floor finish materials based on occupancy classification.

9.2.3 Decorative materials and trim.
Decorative materials and trim shall be restricted by combustibility, fire performance or flame propagation performance criteria in accordance with Clause 9.6.

9.2.4 Applicability.
For buildings in flood hazard areas as established in this Code, interior finishes, trim and decorative materials below the elevation required by this Code shall be flood-damage-resistant materials.

9.2.5 Application.
Combustible materials shall be permitted to be used as finish for walls, ceilings, floors and other interior surfaces of buildings.

9.2.6 Windows.
Show windows in the exterior walls of the first storey above grade plane shall be permitted to be of wood or of unprotected metal framing.

9.2.7 Foam plastics.
Foam plastics shall not be used as interior finish except as provided in Clause 9.3.4. Foam plastics shall not be used as interior trim except as provided in Clause 9.6.5 or 27.4.2. This clause shall apply both to exposed foam plastics and to foam plastics used in conjunction with a textile or vinyl facing or cover.

9.3 WALL AND CEILING FINISHES

9.3.1 General.
Interior wall and ceiling finish materials shall be classified for fire performance and smoke development in accordance with Clause 9.3.1 or 9.3.1.2, except as shown in Clauses 9.3.1.3 through 9.3.15. Materials tested in accordance with Clause 9.3.1.1 shall not be required to be tested in accordance with Clause 9.3.1.2.

9.3.1.1 Interior wall and ceiling finish materials tested in accordance with international best practice (e.g. ASTM E84).
Interior wall and ceiling finish materials shall be classified in accordance with international best practice (e.g. ASTM E84) and comply with Clause 9.3.1.1. Materials complying with Clause 9.3.1.1 shall be considered to also comply with the requirements of Class A.

9.3.1.1 Acceptance criteria for testing wall and ceiling finish materials.
The interior finish shall comply with the following:

1. During the 40 kW exposure, flames shall not spread to the ceiling.
2. The flame shall not spread to the outer extremity of the sample on any wall or ceiling.
3. Flashover shall not occur.
4. The peak heat release rate throughout the test shall not exceed 800 kW.
5. The total smoke released throughout the test shall not exceed 1,000 m$^2$.

9.3.1.2 Interior wall and ceiling finish materials tested in accordance with ASTM E84.

Interior wall and ceiling finish materials shall be classified in accordance with ASTM E84. Such interior finish materials shall be grouped in the following classes in accordance with their flame spread and smoke-developed indices.

- **Class A** = Flame spread index 0-25; smoke-developed index 0-450.
- **Class B** = Flame spread index 26-75; smoke-developed index 0-450.
- **Class C** = Flame spread index 76-200; smoke-developed index 0-450.

**Exception:** Materials tested in accordance with Clause 9.3.1.1 and as indicated in Clauses 9.3.1.3 through 9.3.13.

9.3.1.3 Interior wall and ceiling finish materials with different requirements.

The materials indicated in Clauses 9.3.2 through 9.3.13 shall be tested as indicated in the corresponding clauses.

9.3.2 Thickness exemption.

Materials having a thickness less than 0.9 mm (0.036 inch) applied directly to the surface of walls or ceilings shall not be required to be tested.

9.3.3 Heavy timber exemption.

Exposed portions of building elements complying with the requirements for buildings of heavy timber construction in Clause 7.2.4 or clause 24.4.11 shall not be subject to interior finish requirements except in interior exit stairways, interior exit ramps, and exit passageways.

9.3.4 Foam plastics.

Foam plastics shall not be used as interior finish except as provided in Clause 27.3.9. This clause shall apply both to exposed foam plastics and to foam plastics used in conjunction with a textile or vinyl facing or cover.

9.3.5 Textile wall coverings.

Where used as interior wall finish materials, textile wall coverings, including materials having woven or nonwoven, napped, tufted, looped or similar surface and carpet and similar textile materials, shall be tested in the manner intended for use, using the product-mounting system, including adhesive, and shall comply with the requirements of one of the following: Clause 9.3.1.1, 803.5.1 or 9.3.5.2.

9.3.5.1 Room corner test for textile wall coverings and expanded vinyl wall coverings.

Textile wall coverings and expanded vinyl wall coverings shall meet the criteria of Clause 9.3.5.1.1 when tested in the manner intended for use in accordance with the Method B protocol of NFPA 265 using the product-mounting system, including adhesive.

9.3.5.1.1 Acceptance criteria for NFPA 265.

The interior finish shall comply with the following:

1. During the 40 kW exposure, flames shall not spread to the ceiling.
2. The flame shall not spread to the outer extremities of the samples on the 203 by 305 mm (8-foot by 12-foot) walls.
3. Flashoverv, as defined in NFPA 265, shall not occur.
4. The total smoke release throughout the test shall not exceed 1,000 m$^2$.

9.3.5.2 Acceptance criteria for textile and expanded vinyl wall or ceiling coverings tested to ASTM E84.

Textile wall and ceiling coverings and expanded vinyl wall and ceiling coverings shall have a Class A flame spread index in accordance with ASTM E84 and be protected by an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2. Test specimen preparation and mounting shall be in accordance with ASTM E2404.
9.3.6 Textile ceiling coverings.
Where used as interior ceiling finish materials, textile ceiling coverings, including materials having woven or nonwoven, napped, tufted, looped or similar surface and carpet and similar textile materials, shall be tested in the manner intended for use, using the product-mounting system, including adhesive, and shall comply with the requirements of Clause 9.3.1.1 or 9.3.5.2.

9.3.7 Expanded vinyl wall coverings.
Where used as interior wall finish materials, expanded vinyl wall coverings shall be tested in the manner intended for use, using the product-mounting system, including adhesive, and shall comply with the requirements of one of the following: Clause 9.3.1.1, 9.3.5.1 or 9.3.5.2.

9.3.8 Expanded vinyl ceiling coverings.
Where used as interior ceiling finish materials, expanded vinyl ceiling coverings shall be tested in the manner intended for use, using the product mounting system, including adhesive, and shall comply with the requirements of Clause 9.3.1.1 or 9.3.5.2.

9.3.9 High-density polyethylene (HDPE) and polypropylene (PP).
Where high-density polyethylene or polypropylene is used as an interior finish, it shall comply with Clause 9.3.1.1.

9.3.10 Site-fabricated stretch systems.
Where used as interior wall or interior ceiling finish materials, site-fabricated stretch systems containing all three components described in the definition in Part 2 shall be tested in the manner intended for use, and shall comply with the requirements of Clause 9.3.1.1 or 9.3.1.2. If the materials are tested in accordance with ASTM E84, specimen preparation and mounting shall be in accordance with ASTM E2573.

9.3.11 Laminated products factory produced with a wood substrate.
Laminated products factory produced with a wood substrate shall comply with one of the following:

1. The laminated product shall meet the criteria of Clause 9.3.1.1.1 when tested in accordance with international best practice (e.g. ASTM E84) using the product-mounting system, including adhesive.

2. The laminated product shall have a Class A, B, or C flame spread index and smoke-developed index, based on the requirements of Table 9.3.13, in accordance with ASTM E84. Test specimen preparation and mounting shall be in accordance with ASTM E2579.

9.3.12 Facings or wood veneers intended to be applied on site over a wood substrate.
Facings or veneers intended to be applied on site over a wood substrate shall comply with one of the following:

1. The facing or veneer shall meet the criteria of Clause 9.3.1.1.1 when tested in accordance with ASTM E84 using the product mounting system, including adhesive.

2. The facing or veneer shall have a Class A, B or C flame spread index and smoke-developed index, based on the requirements of Table 9.3.13, in accordance with ASTM E84. Test specimen preparation and mounting shall be in accordance with ASTM E2404.

9.3.13 Interior finish requirements based on occupancy.
Interior wall and ceiling finish shall have a flame spread index not greater than that specified in Table 9.3.13 for the group and location designated. Interior wall and ceiling finish materials tested in accordance with international best practice (e.g. NFPA 286) and meeting the acceptance criteria of Clause 9.3.1.1.1, shall be permitted to be used where a Class A classification in accordance with ASTM E84 is required.
### TABLE 9.3.13 INTERIOR WALL AND CEILING FINISH REQUIREMENTS BY OCCUPANCY²

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SPRINKLERED</th>
<th>NONSPRINKLERED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interior exit stairways and ramps and exit passageways a, b</td>
<td>Corridors and enclosure for exit access stairways and ramps</td>
</tr>
<tr>
<td>A-1 &amp; A-2</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>A-3, A-4, A-5</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>B, E, M, R-1</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>R-4</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>F</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>H</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>I-1</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>I-2</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>I-3</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>I-4</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>R-2</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>R-3</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>S</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>U</td>
<td>No restrictions</td>
<td>No restrictions</td>
</tr>
</tbody>
</table>

² For St: 1 inch = 25.4 mm, 1 square foot = 0.0929 m²

### 9.3.14 Stability.

Interior finish materials regulated by this Part shall be applied or otherwise fastened in such a manner that such materials will not readily become detached where subjected to room temperatures of 93°C for not less than 30 minutes.

### 9.3.15 Application of interior finish materials to fire-resistance-rated or noncombustible building elements.
Where interior finish materials are applied on walls, ceilings or structural elements required to have a fire-resistance rating or to be of noncombustible construction, these finish materials shall comply with the provisions of this clause.

9.3.15.1 Direct attachment and furred construction.

Where walls, ceilings or structural elements are required by any provision in this Code to be of fire-resistance-rated or noncombustible construction, the interior finish material shall be applied directly against such construction or to furring strips not exceeding 44 mm, applied directly against such surfaces.

9.3.15.1.1 Furred construction.

If the interior finish material is applied to furring strips, the intervening spaces between such furring strips shall comply with one of the following:

1. Be filled with material that is inorganic or noncombustible.

2. Be filled with material that meets the requirements of a Class A material in accordance with Clause 9.3.1.1 or 9.3.1.2.

3. Be fire blocked at not greater than 2438 mm in every direction in accordance with Clause 8.18.

Exception: Compliance with Item 1, 2 or 3 is not required where the materials used to create the concealed space are noncombustible.

9.3.15.2 Set-out construction.

Where walls and ceilings are required to be of fire-resistance-rated or noncombustible construction and walls are set out or ceilings are dropped distances greater than specified in Clause 9.3.15.1, Class A finish materials, in accordance with Clause 9.3.1.1 or 9.3.1.2, shall be used.

Exceptions:

1. Where interior finish materials are protected on both sides by an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2).

2. Where interior finish materials are attached to noncombustible backing or furring strips installed as specified in Clause 9.3.15.1.1.

3. Where the combustible void is filled with a noncombustible material.

9.3.15.2.1 Hangers and assembly members.

The hangers and assembly members of such dropped ceilings that are below the horizontal fire-resistance-rated floor or roof assemblies shall be of noncombustible materials. The construction of each set-out wall and horizontal fire-resistance-rated floor or roof assembly shall be of fire-resistance-rated construction as required elsewhere in this Code.

Exception: In Type II and IV construction, fire-retardant-treated wood shall be permitted for use as hangers and assembly members of dropped ceilings.

9.3.15.3 Heavy timber construction.

Wall and ceiling finishes of all classes as permitted in this Part that are installed directly against the wood decking or planking of heavy timber construction in Clause 7.2.4 or clause 24.4.11 or to wood furring strips applied directly to the wood decking or planking shall be fire blocked as specified in Clause 9.3.15.1.1.

9.3.15.4 Materials.

An interior wall or ceiling finish material that is not more than 6.4 mm thick shall be applied directly onto the wall, ceiling or structural element without the use of furring strips and shall not be suspended away from the building element to which that finish material it is applied.

Exceptions:

1. Noncombustible interior finish materials.

2. Materials that meet the requirements of Class A materials in accordance with Clause 9.3.1.1 or 9.3.1.2.
where the qualifying tests were made with the material furred out from the noncombustible backing shall be permitted to be used with furring strips.

3. Materials that meet the requirements of Class A materials in accordance with Clause 9.3.1.1 or 9.3.1.2 where the qualifying tests were made with the material suspended away from the noncombustible backing shall be permitted to be used suspended away from the building element.

9.4 INTERIOR FLOOR FINISH

9.4.1 General.
Interior floor finish and floor covering materials shall comply with Clauses 9.4.2 through 9.4.4.2.

Exception: Floor finishes and coverings of a traditional type, such as wood, vinyl, linoleum or terrazzo, and resilient floor covering materials that are not comprised of fibers.

9.4.2 Classification.
Interior floor finish and floor covering materials required by Clause 9.4.4.2 to be of Class I or II materials shall be classified in accordance with ASTM E648. The classification referred to herein corresponds to the classifications determined by ASTM E648 as follows: Class I, \( 0.45 \text{ watts/cm}^2 \) or greater; Class II, \( 0.22 \text{ watts/cm}^2 \) or greater.

9.4.3 Testing and identification.
Interior floor finish and floor covering materials shall be tested by an agency in accordance with ASTM E648 and identified by a hang tag or other suitable method so as to identify the manufacturer or supplier and style, and shall indicate the interior floor finish or floor covering classification in accordance with Clause 9.4.2. Carpet-type floor coverings shall be tested as proposed for use, including underlayment. Test reports confirming the information provided in the manufacturer’s product identification shall be furnished to the building official upon request.

9.4.4 Interior floor finish requirements.
Interior floor covering materials shall comply with Clauses 9.4.4.1 and 9.4.4.2 and interior floor finish materials shall comply with Clause 9.4.4.2.

9.4.4.1 Test requirement.
In all occupancies, interior floor covering materials shall comply with the requirements of ASTM D2859.

9.4.4.2 Minimum critical radiant flux.
In all occupancies, interior floor finish and floor covering materials in enclosures for stairways and ramps, exit passageways, corridors and rooms or spaces not separated from corridors by partitions extending from the floor to the underside of the ceiling shall withstand a minimum critical radiant flux. The minimum critical radiant flux shall be not less than Class I in Groups I-1, I-2 and I-3 and not less than Class II in Groups A, B, E, H, I-4, M, R-1, R-2 and S.

Exception: Where a building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.1.2, Class II materials are permitted in any area where Class I materials are required, and materials complying with ASTM D2859 are permitted in any area where Class II materials are required.

9.5 COMBUSTIBLE MATERIALS IN TYPES I CONSTRUCTION

9.5.1 Application.
Combustible materials installed on or embedded in floors of buildings of Type I construction shall comply with Clauses 9.5.1.1 through 805.1.3.

Exception: Stages and platforms constructed in accordance with this Code respectively.

9.5.1.1 Subfloor construction.
Floor sleepers, bucks and nailing blocks shall not be constructed of combustible materials, unless the space between the fire-resistant floor assembly and the flooring is either solidly filled with noncombustible materials or
fireblocked in accordance with Clause 8.18, and provided that such open spaces shall not extend under or through permanent partitions or walls.

9.5.1.2 Wood finish flooring.
Wood finish flooring is permitted to be attached directly to the embedded or fireblocked wood sleepers and shall be permitted where cemented directly to the top surface of fire-resistance-rated floor assemblies or directly to a wood subfloor attached to sleepers as provided for in Clause 9.5.1.1.

9.5.1.3 Insulating boards.
Combustible insulating boards not more than 12.7 mm (1/2 inch) thick and covered with finish flooring are permitted where attached directly to a noncombustible floor assembly or to wood subflooring attached to sleepers as provided for in Clause 9.5.1.1.

9.6 DECORATIVE MATERIALS AND TRIM

9.6.1 General.
The following requirements shall apply to all occupancies:

1. Furnishings or decorative materials of an explosive or highly flammable character shall not be used.

2. Fire-retardant coatings in existing buildings shall be maintained so as to retain the effectiveness of the treatment under service conditions encountered in actual use.

3. Furnishings or other objects shall not be placed to obstruct exits, access thereto, egress therefrom or visibility thereof.

4. The permissible amount of decorative vegetation and noncombustible decorative materials shall not be limited.

9.6.2 Combustible decorative materials.
In Groups A, B, E, I, M and R-1 and in dormitories in Group R-2, curtains, draperies, fabric hangings and similar combustible decorative materials suspended from walls or ceilings shall comply with Clause 9.6.4 and shall not exceed 10 percent of the specific wall or ceiling area to which such materials are attached.

Fixed or movable walls and partitions, paneling, wall pads and crash pads applied structurally or for decoration, acoustical correction, surface insulation or other purposes shall be considered to be interior finish, shall comply with Clause 9.3 and shall not be considered to be decorative materials or furnishings.

Exceptions:

1. In auditoriums in Group A, the permissible amount of curtains, draperies, fabric hangings and similar combustible decorative materials suspended from walls or ceilings shall not exceed 75 percent of the aggregate wall area where the building is equipped throughout with an approved automatic sprinkler system in accordance with Clause 10.3.3.1.1 and where the material is installed in accordance with Clause 9.3.15 of this Code.

2. In Group R-2 dormitories, within sleeping units and dwelling units, the permissible amount of curtains, draperies, fabric hangings and similar decorative materials suspended from walls or ceiling shall not exceed 50 percent of the aggregate wall areas where the building is equipped throughout with an approved automatic sprinkler system installed in accordance with Clause 10.3.3.1.

3. In Group B and M occupancies, the amount of combustible fabric partitions suspended from the ceiling and not supported by the floor shall comply with Clause 9.6.4 and shall not be limited.

4. The 10-percent limit shall not apply to curtains, draperies, fabric hangings and similar combustible decorative materials used as window coverings.

9.6.3 Occupancy-based requirements.
Occupancy-based requirements for combustible decorative materials, other than decorative vegetation, not complying with
Clause 9.6.4 shall comply with Clauses 9.7.5.1 through 9.7.5.6 of the Ghana Fire Code.

9.6.4 Acceptance criteria and reports.
Where required to exhibit improved fire performance, curtains, draperies, fabric hangings and similar combustible decorative materials suspended from walls or ceilings shall be tested by an approved agency and meet the flame propagation performance criteria, or exhibit a maximum heat release rate of 100 kW when tested using the 20 kW ignition source. Reports of test results shall be prepared in accordance with the test method used and furnished to the building official upon request.

9.6.5 Foam plastic.
Foam plastic used as trim in any occupancy shall comply with Clause 27.4.2.

9.6.6 Pyroxylin plastic.
Imitation leather or other material consisting of or coated with a pyroxylin or similarly hazardous base shall not be used in Group A occupancies.

9.6.7 Interior trim.
Material, other than foam plastic used as interior trim, shall have a minimum Class C flame spread and smoke-developed index when tested in accordance with ASTM E84, as described in Clause 9.3.1.2. Combustible trim, excluding handrails and guardrails, shall not exceed 10 percent of the specific wall or ceiling area to which it is attached.

9.6.8 Interior floor-wall base.
Interior floor-wall base that is 152 mm (6 inches) or less in height shall be tested in accordance with Clause 9.4.2 and shall be not less than Class II. Where a Class I floor finish is required, the floor-wall base shall be Class I.

Exception: Interior trim materials that comply with Clause 9.6.7.

9.7 INSULATION

9.7.1 Insulation.
Thermal and acoustical insulation shall comply with Clause 3.1 in addition to requirements in this Clause.
9.10.2.1 Waterproofing of interior finishes

Waterproof finish shall be provided to a height of not less than 1.8m above the floor in shower stalls, 1.2m above the rims of bathtubs equipped with showers and 400mm above the rims of bathtubs not equipped with showers.

9.10.2.2 Waterproof finish

Waterproof finish shall consist of granite, marble, ceramic, plastic or metal tile, sheet vinyl or linoleum etc.

9.10.3 Wall tile

9.10.3.1 Wall tile base and adhesive

Ceramic tile shall be set in a mortar base or applied with adhesive. Plastic tile shall be applied with an adhesive.

9.10.3.2 Mortar for ceramic tile

When ceramic tile is applied to a mortar base the cementitious material shall consist of one part Portland cement to not more than ¼ part of lime or clay pozzolana by volume. This shall be mixed with not less than three nor more than five parts of sand per part of cementitious material by volume. Ceramic tile applied to a mortar base shall be thoroughly soaked and pressed into place forcing the mortar into the joints while the tile is wet.

9.10.3.3 Adhesive for ceramic tile

Adhesives to attach ceramic or plastic tile shall be applied to the finish coat or brown coat of plaster that has been steel-trowelled to an even surface or to masonry provided the masonry has an even surface.

9.11 FLOORING

9.11.1 General

9.11.1.1 Finished flooring shall be provided in all residential occupancies.

9.11.2 Wood strip flooring

9.11.2.1 Dimensions

The thickness of wood strip flooring shall conform to Table 9.21.2A

<table>
<thead>
<tr>
<th>Type of Flooring</th>
<th>Maximum Joist Spacing, mm</th>
<th>Minimum Actual Thickness of Flooring, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With Sub-floor</td>
</tr>
<tr>
<td>Hardwood Interior/Exterior Use</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>32</td>
</tr>
</tbody>
</table>

9.11.2.2 Underlay

Wood strip flooring shall not be laid parallel to timber sub-flooring unless a separate underlay is provided.

9.11.2.3 Laying of wood strip flooring

If wood strip flooring is applied without a subfloor, it shall be laid at right angles to the joists so that end joists are staggered and occur over supports or are end matched. It
shall be laid so that no two adjoining strips break joints in the same space between supports and each strip bears on no fewer than two supports.

9.11.3 Parquet flooring

9.11.3.1 Adhesive used to attach parquet block flooring shall be suitable for bonding wood to the applicable subfloor material.

9.11.4 Ceramic tile

9.11.4.1 Ceramic tile shall be set in a mortar bed or applied to a sound smooth base with a suitable adhesive.
PART 10: FIRE PROTECTION AND LIFE SAFETY SYSTEMS

User note:

About this part: Part 10 prescribes the minimum requirements for active fire protection equipment systems to perform the functions of detecting a fire, alerting the occupants or fire department of a fire emergency, mass notification, gas detection, controlling smoke and controlling or extinguishing the fire. Generally, the requirements are based on the occupancy, the height and the area of the building, because these are the factors that most affect firefighting capabilities and the relative hazard of a specific building or portion thereof.

10.1 GENERAL

10.1.1 Scope.

The provisions of this part shall specify where fire protection and life safety systems are required and shall apply to the design, installation and operation of fire protection systems.

10.1.2 Fire protection systems.

Fire protection systems shall be installed, repaired, operated and maintained in accordance with this Code and the Ghana Fire Code.

Any fire protection system for which an exception or reduction to the provisions of this Code has been granted shall be considered to be a required system.

Exception: Any fire protection system or portion thereof not required by this Code shall be permitted to be installed for partial or complete protection provided that such system meets the requirements of this Code.

10.1.3 Modifications.

Persons shall not remove or modify any fire protection system installed or maintained under the provisions of this Code without the approval by the Ghana National Fire Service.

10.1.4 Threads.

Threads provided for Fire Service connections to sprinkler systems, standpipes, yard hydrants or any other fire hose connection shall be compatible with the connections used by the Ghana National Fire Service.

10.1.5 Acceptance tests.

Fire protection systems shall be tested in accordance with the requirements of this Code. The tests shall be conducted in the presence of the Fire Inspector. Tests required by this Code and the standards listed in this Code shall be conducted at the expense of the owner or the owner's authorized agent. It shall be unlawful to occupy portions of a structure until the required fire protection systems within that portion of the structure have been tested and approved.

10.1.6 Supervisory service.

Where required, fire protection systems shall be monitored by an accredited Fire protection service contractor (Service provider) and certified yearly by the Ghana National Fire Service.

10.1.6.1 Automatic sprinkler systems.

Automatic sprinkler systems shall be monitored by an approved supervising station.

Exceptions:

1. A supervising station is not required for automatic sprinkler systems protecting one- and two-family dwellings.

2. Limited area systems in accordance with Clause 10.3.3.8.

10.1.6.2 Integrated testing.

Where two or more fire protection or life safety systems are interconnected, the intended response of subordinate fire protection and life safety systems shall be verified when required testing of the initiating system is conducted. In addition, integrated testing shall be performed in accordance with Clauses 10.6.2.1 and 10.6.2.2.

10.1.6.2.1 High-rise buildings.

For high-rise buildings, integrated testing shall comply with the Ghana Fire Code, with an integrated test performed prior to issuance of the certificate of occupancy and at intervals not exceeding 10 years, unless otherwise specified.
by an integrated system test plan prepared in accordance with the Ghana Fire Code. If an equipment failure is detected during integrated testing, a repeat of the integrated test shall not be required, except as necessary to verify operation of fire protection or life safety functions that are initiated by equipment that was repaired or replaced.

10.1.6.2.2 Smoke control systems.
Where a fire alarm system is integrated with a smoke control system as outlined in Clause 10.9, integrated testing shall comply with the Ghana Fire Code, with an integrated test performed prior to issuance of the certificate of occupancy and at intervals not exceeding 10 years, unless otherwise specified by an integrated system test plan prepared in accordance with the Ghana Fire Code. If an equipment failure is detected during integrated testing, a repeat of the integrated test shall not be required, except as necessary to verify operation of fire protection or life safety functions that are initiated by equipment that was repaired or replaced.

10.1.6.3 Fire alarm systems.
Fire alarm systems required by the provisions of Clause 10.7.2 of this Code and Clauses 10.7.2 and 10.7.9 of the Ghana Fire Code shall be monitored by an approved supervising station in accordance with Clause 10.7.6.6 of this Code.

Exceptions:
1. Single- and multiple-station smoke alarms required by Clause 10.7.2.10.
2. Smoke detectors in Group I-3 occupancies.
3. Supervisory service is not required for automatic sprinkler systems in one- and two-family dwellings.

10.1.6.4 Group H.
Supervision and monitoring of emergency alarm, detection and automatic fire-extinguishing systems in Group H occupancies shall be in accordance with the Ghana Fire Code.

10.1.7 Fire areas.
Where buildings, or portions thereof, are divided into fire areas so as not to exceed the limits established for requiring a fire protection system in accordance with this part, such fire areas shall be separated by fire walls constructed in accordance with Clause 8.6, fire barriers constructed in accordance with Clause 8.7, or horizontal assemblies constructed in accordance with Clause 8.11, or a combination thereof having a fire-resistance rating of not less than that determined in accordance with Clause 8.7.3.10.

10.2 FIRE PUMP AND RISER ROOM SIZE

10.2.1 Pump and riser room size.
Where provided, fire pump rooms and automatic sprinkler system riser rooms shall be designed with adequate space for all equipment necessary for the installation, as defined by the manufacturer, with sufficient working room around the stationary equipment. Clearances around equipment to elements of permanent construction, including other installed equipment and appliances, shall be sufficient to allow inspection, service, repair or replacement without removing such elements of permanent construction or disabling the function of a required fire-resistance-rated assembly. Fire pump and automatic sprinkler system riser rooms shall be provided with doors and unobstructed passageways large enough to allow removal of the largest piece of equipment.

10.2.1.1 Access.
Automatic sprinkler system risers, fire pumps and controllers shall be provided with ready access. Where located in a fire pump room or automatic sprinkler system riser room, the door shall be permitted to be locked provided that the key is available at all times.

10.2.2.1 Marking on access doors.
Access doors for automatic sprinkler system riser rooms and fire pump rooms shall be labeled with an approved sign. The lettering shall be in contrasting color to the background. Letters shall have a minimum height of 51 mm (2 inches) with a minimum stroke of 10 mm (3/8 inch).
10.2.1.3 Environment.

Automatic sprinkler system riser rooms and fire pump rooms shall be maintained at a temperature of not less than 4°C (40°F). Heating units shall be permanently installed.

10.2.1.4 Lighting.

Permanently installed artificial illumination shall be provided in the automatic sprinkler system riser rooms and fire pump rooms.

10.3 AUTOMATIC SPRINKLER SYSTEMS

10.3.1 General.

Automatic sprinkler systems shall comply with this clause.

10.3.1.1 Alternative protection.

Alternative automatic fire-extinguishing systems complying with Clause 10.4 shall be permitted instead of automatic sprinkler protection where recognized by the applicable standard and approved by the fire Code official.

10.3.2 Where required.

Approved automatic sprinkler systems in new buildings and structures shall be provided in the locations described in Clauses 10.3.2.1 through 10.3.2.12.

**Exception:** Spaces or areas in telecommunications buildings used exclusively for telecommunications equipment, associated electrical power distribution equipment, batteries and standby engines, provided that those spaces or areas are equipped throughout with an automatic smoke detection system in accordance with Clause 10.7.2 and are separated from the remainder of the building by not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or not less than 2-hour horizontal assemblies constructed in accordance with Clause 8.11, or both.

10.3.2.1 Group A.

An automatic sprinkler system shall be provided throughout buildings and portions thereof used as Group A occupancies as provided in this clause.

10.3.2.1.1 Group A-1.

An automatic sprinkler system shall be provided throughout stories containing Group A-1 occupancies and throughout all stories from the Group A-1 occupancy to and including the levels of exit discharge serving that occupancy where one of the following conditions exists:

1. The fire area exceeds 1115 m$^2$ (12,000 square feet).
2. The fire area has an occupant load of 300 or more.
3. The fire area is located on a floor other than a level of exit discharge serving such occupancies.
4. The fire area contains a multitheater complex.

10.3.2.1.2 Group A-2.

An automatic sprinkler system shall be provided throughout stories containing Group A-2 occupancies and throughout all stories from the Group A-2 occupancy to and including the levels of exit discharge serving that occupancy where one of the following conditions exists:

1. The fire area exceeds 464 m$^2$ (5,000 square feet).
2. The fire area has an occupant load of 100 or more.
3. The fire area is located on a floor other than a level of exit discharge serving such occupancies.

10.3.2.1.3 Group A-3.

An automatic sprinkler system shall be provided throughout stories containing Group A-3 occupancies and throughout all stories from the Group A-3 occupancy to and including
the levels of exit discharge serving that occupancy where one of the following conditions exists:

1. The fire area exceeds 1115 m$^2$ (12,000 square feet).
2. The fire area has an occupant load of 300 or more.
3. The fire area is located on a floor other than a level of exit discharge serving such occupancies.

10.3.2.1.4 Group A-4.

An automatic sprinkler system shall be provided throughout stories containing Group A-4 occupancies and throughout all stories from the Group A-4 occupancy to and including the levels of exit discharge serving that occupancy where one of the following conditions exists:

1. The fire area exceeds 1115 m$^2$ (12,000 square feet).
2. The fire area has an occupant load of 300 or more.
3. The fire area is located on a floor other than a level of exit discharge serving such occupancies.

10.3.2.1.5 Group A-5.

An automatic sprinkler system shall be provided for all enclosed Group A-5 accessory use areas in excess of 93 m² (1,000 square feet).

10.3.2.1.5.1 Spaces under grandstands or bleachers.

Enclosed spaces under grandstands or bleachers shall be equipped with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 where either of the following exist:

1. The enclosed area is 93 m² (1,000 square feet) or less and is not constructed in accordance with Clause 11.29.1.1.1.

2. The enclosed area exceeds 93 m² (1,000 square feet).

10.3.2.1.6 Assembly occupancies on roofs.

Where an occupied roof has an assembly occupancy with an occupant load exceeding 100 for Group A-2 and 300 for other Group A occupancies, all floors between the occupied roof and the level of exit discharge shall be equipped with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

Exception: Open parking garages of Type I or Type II construction.

10.3.2.1.7 Multiple fire areas.

An automatic sprinkler system shall be provided where multiple fire areas of Group A-1, A-2, A-3 or A-4 occupancies share exit or exit access components and the combined occupant load of theses fire areas is 300 or more.

10.2.2 Ambulatory care facilities.

An automatic sprinkler system shall be installed throughout the entire floor containing an ambulatory care facility where either of the following conditions exist at any time:

1. Four or more care recipients are incapable of self-preservation.
2. One or more care recipients that are incapable of self-preservation are located at other than the level of exit discharge serving such a facility.

In buildings where ambulatory care is provided on levels other than the level of exit discharge, an automatic sprinkler system shall be installed throughout the entire floor as well as all floors below where such care is provided, and all floors between the level of ambulatory care and the nearest level of exit discharge, the level of exit discharge, and all floors below the level of exit discharge.

Exception: Floors classified as an open parking garage are not required to be sprinklered.
10.3.2.3 Group E.
An automatic sprinkler system shall be provided for Group E occupancies as follows:

1. Throughout all Group E fire areas greater than 12,000 square feet \( (1115 \text{ m}^2) \) in area.

2. The Group E fire area is located on a floor other than a level of exit discharge serving such occupancies.

**Exception:** In buildings where every classroom has not fewer than one exterior exit door at ground level, an automatic sprinkler system is not required in any area below the lowest level of exit discharge serving that area.

3. The Group E fire area has an occupant load of 300 or more.

10.3.2.4 Group F-1.
An automatic sprinkler system shall be provided throughout all buildings containing a Group F-1 occupancy where one of the following conditions exists:

1. A Group F-1 fire area exceeds 12,000 square feet \( (1115 \text{ m}^2) \).

2. A Group F-1 fire area is located more than three stories above grade plane.

3. The combined area of all Group F-1 fire areas on all floors, including any mezzanines, exceeds 24,000 square feet \( (2230 \text{ m}^2) \).

4. A Group F-1 occupancy used for the manufacture of upholstered furniture or mattresses exceeds 2,500 square feet \( (232 \text{ m}^2) \).

10.3.2.4.1 Woodworking operations.
An automatic sprinkler system shall be provided throughout all Group F-1 occupancy fire areas that contain woodworking operations in excess of 2,500 square feet \( (232 \text{ m}^2) \) in area that generate finely divided combustible waste or use finely divided combustible materials.

10.3.2.5 Group H.
Automatic sprinkler systems shall be provided in high-hazard occupancies as required in Clauses 10.3.2.5.1 through 10.3.2.5.3.

10.3.2.5.1 General.
An automatic sprinkler system shall be installed in Group H occupancies.

10.3.2.5.2 Group H-5 occupancies.
An automatic sprinkler system shall be installed throughout buildings containing Group H-5 occupancies. The design of the sprinkler system shall be not less than that required by this Code for the occupancy hazard classifications in accordance with Table 10.3.2.5.2.

Where the design area of the sprinkler system consists of a corridor protected by one row of sprinklers, the maximum number of sprinklers required to be calculated is 13.

**TABLE 10.3.2.5.2**
GROUP H-5 SPRINKLER DESIGN CRITERIA

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>OCCUPANCY HAZARD CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabrication areas</td>
<td>Ordinary Hazard Group 2</td>
</tr>
<tr>
<td>Service corridors</td>
<td>Ordinary Hazard Group 2</td>
</tr>
<tr>
<td>Storage rooms without dispensing</td>
<td>Ordinary Hazard Group 2</td>
</tr>
<tr>
<td>Storage rooms with dispensing</td>
<td>Extra Hazard Group 2</td>
</tr>
<tr>
<td>Corridors</td>
<td>Ordinary Hazard Group 2</td>
</tr>
</tbody>
</table>

10.3.2.5.3 Pyroxylin plastics.
An automatic sprinkler system shall be provided in buildings, or portions thereof, where cellulose nitrate film or pyroxylin plastics are manufactured, stored or handled in quantities exceeding 45 kg (100 pounds).

10.3.2.6 Group I.
An automatic sprinkler system shall be provided throughout buildings with a Group I fire area.
Exceptions:

1. An automatic sprinkler system installed in accordance with Clause 10.3.3.1.2 shall be permitted in Group I-1, Condition 1 facilities.

2. An automatic sprinkler system is not required where Group I-4 day care facilities are at the level of exit discharge and where every room where care is provided has not less than one exterior exit door.

3. In buildings where Group I-4 day care is provided on levels other than the level of exit discharge, an automatic sprinkler system installed on the entire floor where care is provided, all floors between the level of care and the level of exit discharge, and all floors below the level of exit discharge other than areas classified as an open parking garage.

10.3.2.7 Group M.

An automatic sprinkler system shall be provided throughout buildings containing a Group M occupancy where one of the following conditions exists:

1. A Group M fire area exceeds $1115 \text{ m}^2$ (12,000 square feet).

2. A Group M fire area is located more than three stories above grade plane.

3. The combined area of all Group M fire areas on all floors, including any mezzanines, exceeds $2230 \text{ m}^2$ (24,000 square feet).

4. A Group M occupancy used for the display and sale of upholstered furniture or mattresses exceeds $464 \text{ m}^2$ (5,000 square feet).

10.3.2.7.1 High-piled storage.

An automatic sprinkler system shall be provided in accordance with the Ghana Fire Code in all buildings of Group M where storage of merchandise is in high-piled or rack storage arrays.

10.3.2.8 Group R.

An automatic sprinkler system installed in accordance with Clause 10.3.3 shall be provided throughout all buildings with a Group R fire area.

10.3.2.8.1 Group R-3.

An automatic sprinkler system installed in accordance with Clause 10.3.3.1.3 shall be permitted in Group R-3 occupancies.

10.3.2.8.2 Group R-4, Condition 1.

An automatic sprinkler system installed in accordance with Clause 10.3.3.1.3 shall be permitted in Group R-4, Condition 1 occupancies.

10.3.2.8.3 Group R-4, Condition 2.

An automatic sprinkler system installed in accordance with Clause 10.3.3.1.2 shall be permitted in Group R-4, Condition 2 occupancies.

10.3.2.8.4 Care facilities.

An automatic sprinkler system installed in accordance with Clause 10.3.3.1.3 shall be permitted in care facilities with five or fewer individuals in a single-family dwelling.

10.3.2.9 Group S-1.

An automatic sprinkler system shall be provided throughout all buildings containing a Group S-1 occupancy where one of the following conditions exists:

1. A Group S-1 fire area exceeds $1115 \text{ m}^2$ (12,000 square feet).

2. A Group S-1 fire area is located more than three stories above grade plane.

3. The combined area of all Group S-1 fire areas on all floors, including
any mezzanines, exceeds 2230 m$^2$ (24,000 square feet).

4. A Group S-1 fire area used for the storage of commercial motor vehicles where the fire area exceeds 464 m$^2$ (5,000 square feet).

5. A Group S-1 occupancy used for the storage of upholstered furniture or mattresses exceeds 232 m$^2$ (2,500 square feet).

10.3.2.9.1 Repair garages.

An automatic sprinkler system shall be provided throughout all buildings used as repair garages in accordance with this, as shown:

1. Buildings having two or more stories above grade plane, including basements, with a fire area containing a repair garage exceeding 929 m$^2$ (10,000 square feet).

2. Buildings not more than one story above grade plane, with a fire area containing a repair garage exceeding 1115 m$^2$ (12,000 square feet).


4. A Group S-1 fire area used for the repair of commercial motor vehicles where the fire area exceeds 464 m$^2$ (5,000 square feet).

10.3.2.9.2 Bulk storage of tires.

Buildings and structures where the area for the storage of tires exceeds 566 m$^3$ (20,000 cubic feet) shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

10.3.2.10 Group S-2 enclosed parking garages.

An automatic sprinkler system shall be provided throughout buildings classified as enclosed parking garages in accordance with Clause 4.6.6 where either of the following conditions exists:

1. Where the fire area of the enclosed parking garage exceeds 1115 m$^2$ (12,000 square feet).

2. Where the enclosed parking garage is located beneath other groups.

**Exception:** Enclosed parking garages located beneath Group R-3 occupancies.

10.3.2.10.1 Commercial parking garages.

An automatic sprinkler system shall be provided throughout buildings used for storage of commercial motor vehicles where the fire area exceeds 5,000 square feet (464 m$^2$).

10.3.2.11 Specific building areas and hazards.

In all occupancies other than Group U, an automatic sprinkler system shall be installed for building design or hazards in the locations set forth in Clauses 10.3.2.11.1 through 10.3.2.11.6.

10.3.2.11.1 Stories without openings.

An automatic sprinkler system shall be installed throughout all stories, including basements, of all buildings where the floor area exceeds 139.4 m$^2$ (1,500 square feet) and where the storey does not comply with the following criteria for exterior wall openings:

1. Openings below grade that lead directly to ground level by an exterior stairway complying with this Code or an outside ramp complying with Clause 11.12. Openings shall be located in each 15 240 mm (50 linear feet), or fraction thereof, of exterior wall in the storey on not less than one side. The required openings shall be distributed such that the lineal distance between adjacent openings does not exceed 15 240 mm (50 feet).
2. Openings entirely above the adjoining ground level totaling not less than 1.86 m² (20 square feet) in each 15 240 mm (50 linear feet), or fraction thereof, of exterior wall in the storey on not fewer than one side. The required openings shall be distributed such that the lineal distance between adjacent openings does not exceed 15 240 mm (50 feet). The height of the bottom of the clear opening shall not exceed 1118 mm (44 inches) measured from the floor.

10.3.2.11.1.1 Opening dimensions and access.

Openings shall have a minimum dimension of not less than 762 mm (30 inches). Access to such openings shall be provided for the fire department from the exterior and shall not be obstructed in a manner such that fire fighting or rescue cannot be accomplished from the exterior.

10.3.2.11.1.2 Openings on one side only.

Where openings in a storey are provided on only one side and the opposite wall of such storey is more than 22 860 mm (75 feet) from such openings, the storey shall be equipped throughout with an approved automatic sprinkler system, or openings shall be provided on not fewer than two sides of the storey.

10.3.2.11.1.3 Basements.

Where any portion of a basement is located more than 22 860 mm (75 feet) from openings required by Clause 10.3.2.11.1, or where walls, partitions or other obstructions are installed that restrict the application of water from hose streams, the basement shall be equipped throughout with an approved automatic sprinkler system.

10.3.2.11.2 Rubbish and linen chutes.

An automatic sprinkler system shall be installed at the top of rubbish and linen chutes and in their terminal rooms. Chutes shall have additional sprinkler heads installed at alternate floors and at the lowest intake. Where a rubbish chute extends through a building more than one floor below the lowest intake, the extension shall have sprinklers installed that are recessed from the drop area of the chute and protected from freezing in accordance with Clause 10.3.3.1.1. Such sprinklers shall be installed at alternate floors, beginning with the second level below the last intake and ending with the floor above the discharge. Access to sprinklers in chutes shall be provided for servicing.

10.3.2.11.3 Buildings 55 feet or more in height.

An automatic sprinkler system shall be installed throughout buildings that have one or more stories with an occupant load of 30 or more located 16 764 mm (55 feet) or more above the lowest level of fire department vehicle access, measured to the finished floor.

Exceptions:
1. Open parking structures.
2. Occupancies in Group F-2.

10.3.2.11.4 Ducts conveying hazardous exhausts.

Where required by the International Mechanical Code, automatic sprinklers shall be provided in ducts conveying hazardous exhaust or flammable or combustible materials.

Exception: Ducts where the largest cross-clausal diameter of the duct is less than 254 mm (10 inches).

10.3.2.11.5 Commercial cooking operations.

An automatic sprinkler system shall be installed in commercial kitchen exhaust hood and duct systems where an automatic sprinkler system is used to comply with Clause 10.4.

10.3.2.11.6 Other required suppression systems.

In addition to the requirements of Clause 10.3.2, the provisions indicated in Table 10.3.2.11.6 require the installation of a fire suppression system for certain buildings and areas.

<table>
<thead>
<tr>
<th>TABLE 10.3.2.11.6 ADDITIONAL REQUIRED SUPPRESSION SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBJECT</td>
</tr>
<tr>
<td>Covered and open mall buildings</td>
</tr>
<tr>
<td>High-rise buildings</td>
</tr>
<tr>
<td>Atriums</td>
</tr>
<tr>
<td>Underground structures</td>
</tr>
<tr>
<td>Group I-2</td>
</tr>
<tr>
<td>Stages</td>
</tr>
</tbody>
</table>

340
10.3.2.12 During construction.

Automatic sprinkler systems required during construction, alteration and demolition operations shall be provided in accordance with the Ghana Fire Code.

10.3.3 Installation requirements.

Automatic sprinkler systems shall be designed and installed in accordance with Clauses 10.3.3.1 through 10.3.3.8.

10.3.3.1 Standards.

Sprinkler systems shall be designed and installed in accordance with Clause 10.3.3.1.1 unless otherwise permitted by Clauses 10.3.3.1.2 and 10.3.3.1.3 and other parts of this Code, as applicable.

10.3.3.1.1 NFPA 13 sprinkler systems.

Where the provisions of this Code require that a building or portion thereof be equipped throughout with an automatic sprinkler system in accordance with this clause, sprinklers shall be installed throughout in accordance with the Ghana Fire Code except as provided in Clauses 10.3.3.1.1.1 and 10.3.3.1.1.2.

10.3.3.1.1.1 Exempt locations.

Automatic sprinklers shall not be required in the following rooms or areas where such rooms or areas are protected with an approved automatic fire detection system in accordance with Clause 10.7.2 that will respond to visible or invisible particles of combustion. Sprinklers shall not be omitted from a room merely because it is damp, of fire-resistance-rated construction or contains electrical equipment.

1. A room where the application of water, or flame and water, constitutes a serious life or fire hazard.

2. A room or space where sprinklers are considered undesirable because of the nature of the contents, where approved by the fire Code official.

3. Generator and transformer rooms separated from the remainder of the building by walls and floor/ceiling or roof/ceiling assemblies having a fire-resistance rating of not less than 2 hours.

4. Rooms or areas that are of noncombustible construction with wholly noncombustible contents.

5. Fire service access elevator machine rooms and machinery spaces.

6. Machine rooms, machinery spaces, control rooms and control spaces associated with occupant evacuation elevators designed in accordance with this Code.

10.3.3.1.2 Bathrooms.

In Group R occupancies sprinklers shall not be required in bathrooms that do not exceed 5 m (255 square feet) in area and are located within individual dwelling units or sleeping units, provided that walls and ceilings, including the walls and ceilings behind a shower enclosure or tub, are of noncombustible or limited-combustible materials with a 15-minute thermal barrier rating.

10.3.3.1.2 NFPA 13R sprinkler systems.

Automatic sprinkler systems in Group R occupancies up to and including four stories in height in buildings not exceeding 18 288 mm (60 feet) in height above grade plane shall be permitted to be installed throughout in accordance with the Ghana Fire Code.

The number of stories of Group R occupancies constructed in accordance with Clauses 510.2 and 510.4 shall be measured from the horizontal assembly creating separate buildings.

10.3.3.1.2.1 Balconies and decks.

Sprinkler protection shall be provided for exterior balconies, decks and ground floor patios of dwelling units and sleeping units where either of the following conditions exists:

<table>
<thead>
<tr>
<th>Special amusement buildings</th>
<th>Airport traffic control towers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft hangars</td>
<td>Flammable finishes</td>
</tr>
<tr>
<td>Group H-5 HPM exhaust ducts</td>
<td>Drying rooms</td>
</tr>
<tr>
<td>Live/work units</td>
<td>Children’s play structures</td>
</tr>
<tr>
<td>Buildings containing laboratory suites</td>
<td>Unlimited area buildings</td>
</tr>
<tr>
<td>Incidental uses</td>
<td>Smoke-protected assembly seating</td>
</tr>
<tr>
<td>Sprinkler system requirements as set forth in Clause 10.3.2.11.6 of the Ghana Fire Code</td>
<td></td>
</tr>
</tbody>
</table>
1. The building is of Type IV construction, provided that there is a roof or deck above.

2. Exterior balconies, decks and ground floor patios of dwelling units and sleeping units are constructed in accordance with Clause 8.5.2.3.1, Exception 3.

Sidewall sprinklers that are used to protect such areas shall be located such that their deflectors are within 1 inch (25 mm) to 6 inches (152 mm) below the structural members and a maximum distance of 14 inches (356 mm) below the deck of the exterior balconies and decks that are constructed of open wood joist construction.

10.3.3.1.2.2 Open-ended corridors.

Sprinkler protection shall be provided in open-ended corridors and associated exterior stairways and ramps as specified in Clause 11.27.6, Exception 3.

10.3.3.1.2.3 Attics.

Attic protection shall be provided as follows:

1. Attics that are used or intended for living purposes or storage shall be protected by an automatic sprinkler system.

2. Where fuel-fired equipment is installed in an unsprinklered attic, not fewer than one quick-response intermediate temperature sprinkler shall be installed above the equipment.

3. Where located in a building of Type II, Type III or Type IV construction designed in accordance with Clause 510.2 or 510.4, attics not required by Item 1 to have sprinklers shall comply with one of the following if the roof assembly is located more than 55 feet (16 764 mm) above the lowest level of required fire department vehicle access:

   3.1. Provide automatic sprinkler system protection.

   3.2. Construct the attic using noncombustible materials.

   3.3. Construct the attic using fire-retardant-treated wood complying with Clause 24.3.2.

3.4. Fill the attic with noncombustible insulation.

The height of the roof assembly shall be determined by measuring the distance from the lowest required fire vehicle access road surface adjacent to the building to the eave of the highest pitched roof, the interclause of the highest roof to the exterior wall, or the top of the highest parapet, whichever yields the greatest distance. For the purpose of this measurement, required fire vehicle access roads shall include only those roads that are necessary for compliance with Clause 503 of the Ghana Fire Code.

4. Group R-4, Condition 2 occupancy attics not required by Item 1 to have sprinklers shall comply with one of the following:

4.1. Provide automatic sprinkler system protection.

4.2. Provide a heat detection system throughout the attic that is arranged to activate the building fire alarm system.

4.3. Construct the attic using noncombustible materials.

4.4. Construct the attic using fire-retardant-treated wood complying with Clause 24.3.2.

4.5. Fill the attic with noncombustible insulation.

10.3.3.1.3 NFPA 13D sprinkler systems.

Automatic sprinkler systems installed in one- and two-family dwellings; Group R-3; Group R-4, Condition 1; and townhouses shall be permitted to be installed throughout in accordance with NFPA 13D.

10.3.3.2 Quick-response and residential sprinklers.

Where automatic sprinkler systems are required by this Code, quick-response or residential automatic sprinklers shall be installed in all of the following areas in accordance with Clause 10.3.3.1 and their listings:
1. Throughout all spaces within a smoke compartment containing care recipient sleeping units in Group I-2 in accordance with this Code.

2. Throughout all spaces within a smoke compartment containing treatment rooms in ambulatory care facilities.

3. Dwelling units and sleeping units in Group I-1 and R occupancies.

4. Light-hazard occupancies as defined in the Ghana Fire Code.

10.3.3.3 Obstructed locations.
Automatic sprinklers shall be installed with regard to obstructions that will delay activation or obstruct the water distribution pattern and shall be in accordance with the applicable automatic sprinkler system standard that is being used. Automatic sprinklers shall be installed in or under covered kiosks, displays, booths, concession stands, or equipment that exceeds 1219 mm (4 feet) in width. Not less than a 914 mm (3-foot) clearance shall be maintained between automatic sprinklers and the top of piles of combustible fibers.

Exception: Kitchen equipment under exhaust hoods protected with a fire-extinguishing system in accordance with Clause 10.4.

10.3.3.4 Actuation.
Automatic sprinkler systems shall be automatically actuated unless specifically provided for in this Code.

10.3.3.5 Water supplies.
Water supplies for automatic sprinkler systems shall comply with this clause and the standards referenced in Clause 10.3.3.1. The potable water supply shall be protected against backflow in accordance with the requirements of this clause and the International Plumbing Code. For connections to public waterworks systems, the water supply test used for design of fire protection systems shall be adjusted to account for seasonal and daily pressure fluctuations based on information from the water supply authority and as approved by the fire Code official.

10.3.3.5.1 Domestic services.
Where the domestic service provides the water supply for the automatic sprinkler system, the supply shall be in accordance with this clause.

10.3.3.5.2 Residential combination services.
A single combination water supply shall be allowed provided that the domestic demand is added to the sprinkler demand as required by the Ghana Fire Code.

10.3.3.6 Hose threads.
Fire hose threads and fittings used in connection with automatic sprinkler systems shall be as prescribed by the fire Code official.

10.3.3.7 Fire department connections.
Fire department connections for automatic sprinkler systems shall be installed in accordance with Clause 10.12.

10.3.3.8 Limited area sprinkler systems.
Limited area sprinkler systems shall be in accordance with the standards listed in Clause 10.3.3.1 except as provided in Clauses 10.3.3.8.1 through 10.3.3.8.5.

10.3.3.8.1 Number of sprinklers.
Limited area sprinkler systems shall not exceed six sprinklers in any single fire area.

10.3.3.8.2 Occupancy hazard classification.
Only areas classified by the Ghana Fire Code as Light Hazard or Ordinary Hazard Group 1 shall be permitted to be protected by limited area sprinkler systems.

10.3.3.8.3 Piping arrangement.
Where a limited area sprinkler system is installed in a building with an automatic wet Fire hydrant system, sprinklers shall be supplied by the Fire hydrant system. Where a limited area sprinkler system is installed in a building without an automatic wet Fire hydrant system, water shall be permitted to be supplied by the plumbing system provided that the plumbing system is capable of simultaneously supplying domestic and sprinkler demands.

10.3.3.8.4 Supervision.
Control valves shall not be installed between the water supply and sprinklers unless the
valves are of an approved indicating type that are supervised or secured in the open position.

10.3.3.8.5 Calculations.

Hydraulic calculations in accordance with the Ghana Fire Code shall be provided to demonstrate that the available water flow and pressure are adequate to supply all sprinklers installed in any single fire area with discharge densities corresponding to the hazard classification.

10.3.4 Sprinkler system supervision and alarms.

Valves controlling the water supply for automatic sprinkler systems, pumps, tanks, water levels and temperatures, critical air pressures and waterflow switches on all sprinkler systems shall be electrically supervised by a listed fire alarm control unit.

Exceptions:

1. Automatic sprinkler systems protecting one- and two-family dwellings.
2. Limited area sprinkler systems in accordance with Clause 10.3.3.8.
3. Automatic sprinkler systems installed in accordance with the Ghana Fire Code where a common supply main is used to supply both domestic water and the automatic sprinkler system, and a separate shutoff valve for the automatic sprinkler system is not provided.
4. Jockey pump control valves that are sealed or locked in the open position.
5. Control valves to commercial kitchen hoods, paint spray booths or dip tanks that are sealed or locked in the open position.
6. Valves controlling the fuel supply to fire pump engines that are sealed or locked in the open position.
7. Trim valves to pressure switches in dry, preaction and deluge sprinkler systems that are sealed or locked in the open position.

103.4.1 Monitoring.

Alarm, supervisory and trouble signals shall be distinctly different and shall be automatically transmitted to an approved supervising station or, where approved by the fire Code official, shall sound an audible signal at a constantly attended location.

Exceptions:

1. Underground key or hub valves in roadway boxes provided by the municipality or public utility are not required to be monitored.
2. Backflow prevention device test valves located in limited area sprinkler system supply piping shall be locked in the open position. In occupancies required to be equipped with a fire alarm system, the backflow preventer valves shall be electrically supervised by a tamper switch installed in accordance with ISO 7240 and separately annunciated.

10.3.4.2 Alarms.

An approved audible device, located on the exterior of the building in an approved location, shall be connected to each automatic sprinkler system. Such sprinkler waterflow alarm devices shall be activated by water flow equivalent to the flow of a single sprinkler of the smallest orifice size installed in the system. Where a fire alarm system is installed, actuation of the automatic sprinkler system shall actuate the building fire alarm system.

10.3.4.3 Floor control valves.

Approved supervised indicating control valves shall be provided at the point of connection to the riser on each floor in high-rise buildings.

10.3.5 Testing and maintenance.

Sprinkler systems shall be tested and maintained in accordance with the Ghana Fire Code.

10.4 ALTERNATIVE AUTOMATIC FIRE-EXTINGUISHING SYSTEMS

10.4.1 General.

Automatic fire-extinguishing systems, other than automatic sprinkler systems, shall be designed, installed, inspected, tested and maintained in accordance with the provisions of this clause and the applicable referenced standards.
10.4.2 Where permitted.
Automatic fire-extinguishing systems installed as an alternative to the required automatic sprinkler systems of Clause 10.3 shall be approved by the fire Code official.

10.4.2.1 Restriction on using automatic sprinkler system exceptions or reductions.
Automatic fire-extinguishing systems shall not be considered alternatives for the purposes of exceptions or reductions allowed for automatic sprinkler systems or by other requirements of this Code.

10.4.2.2 Commercial hood and duct systems.
Each required commercial kitchen exhaust hood and duct system required by the Ghana Fire Code to have a Type I hood shall be protected with an approved automatic fire-extinguishing system installed in accordance with this Code.

10.4.3 Installation.
Automatic fire-extinguishing systems shall be installed in accordance with this clause.

10.4.3.1 Electrical wiring.
Electrical wiring shall be in accordance with Ghana Wiring Code.

10.4.3.2 Actuation.
Automatic fire-extinguishing systems shall be automatically actuated and provided with a manual means of actuation in accordance with Clause 10.4.11.1. Where more than one hazard could be simultaneously involved in fire due to their proximity, all hazards shall be protected by a single system designed to protect all hazards that could become involved.

Exception: Multiple systems shall be permitted to be installed if they are designed to operate simultaneously.

10.4.3.3 System interlocking.
Automatic equipment interlocks with fuel shutoffs, ventilation controls, door closers, window shutters, conveyor openings, smoke and heat vents and other features necessary for proper operation of the fire-extinguishing system shall be provided as required by the design and installation standard utilized for the hazard.

10.4.3.4 Alarms and warning signs.
Where alarms are required to indicate the operation of automatic fire-extinguishing systems, distinctive audible and visible alarms and warning signs shall be provided to warn of pending agent discharge. Where exposure to automatic-extinguishing agents poses a hazard to persons and a delay is required to ensure the evacuation of occupants before agent discharge, a separate warning signal shall be provided to alert occupants once agent discharge has begun. Audible signals shall be in accordance with Clause 10.7.5.2.

10.4.3.5 Monitoring.
Where a building fire alarm system is installed, automatic fire-extinguishing systems shall be monitored by the building fire alarm system in accordance with ISO 7240.

10.4.4 Inspection and testing.
Automatic fire-extinguishing systems shall be inspected and tested in accordance with the provisions of this clause prior to acceptance.

10.4.4.1 Inspection.
Prior to conducting final acceptance tests, all of the following items shall be inspected:

1. Hazard specification for consistency with design hazard.
2. Type, location and spacing of automatic- and manual-initiating devices.
3. Size, placement and position of nozzles or discharge orifices.
4. Location and identification of audible and visible alarm devices.
5. Identification of devices with proper designations.
6. Operating instructions.

10.4.4.2 Alarm testing.
Notification appliances, connections to fire alarm systems and connections to approved supervising stations shall be tested in accordance with this clause and Clause 10.7 to verify proper operation.

10.4.4.2.1 Audible and visible signals.
The audibility and visibility of notification appliances signaling agent discharge or system operation, where required, shall be verified.

10.4.4.3 Monitor testing.
Connections to protected premises and supervising station fire alarm systems shall be tested to verify proper identification and retransmission of alarms from automatic fire-extinguishing systems.

10.4.5 Wet-chemical systems.
Wet-chemical extinguishing systems shall be installed, maintained, periodically inspected and tested in accordance with the Ghana Fire Code and their listing. Records of inspections and testing shall be maintained.

10.4.6 Dry-chemical systems.
Dry-chemical extinguishing systems shall be installed, maintained, periodically inspected and tested in accordance with the Ghana Fire Code and their listing. Records of inspections and testing shall be maintained.

10.4.7 Foam systems.
Foam-extinguishing systems shall be installed, maintained, periodically inspected and tested in accordance with the Ghana Fire Code and their listing. Records of inspections and testing shall be maintained.

10.4.8 Carbon dioxide systems.
Carbon dioxide extinguishing systems shall be installed, maintained, periodically inspected and tested in accordance with the Ghana Fire Code and their listing. Records of inspections and testing shall be maintained.

10.4.9 Halon systems.
Halogenated extinguishing systems shall be installed, maintained, periodically inspected and tested in accordance with the Ghana Fire Code and their listing. Records of inspections and testing shall be maintained.

10.4.10 Clean-agent systems.
Clean-agent fire-extinguishing systems shall be installed, maintained, periodically inspected and tested in accordance with the Ghana Fire Code and their listing. Records of inspections and testing shall be maintained.

10.4.11 Automatic water mist systems.
Automatic water mist systems shall be permitted in applications that are consistent with the applicable listing or approvals and shall comply with Clauses 10.4.11.1 through 10.4.11.3.

10.4.11.1 Design and installation requirements.
Automatic water mist systems shall be designed and installed in accordance with Clauses 10.4.11.1.1 through 10.4.11.1.4.

10.4.11.1.1 General.
Automatic water mist systems shall be designed and installed in accordance with the Ghana Fire Code and the manufacturer’s instructions.

10.4.11.1.2 Actuation.
Automatic water mist systems shall be automatically actuated.

10.4.11.1.3 Water supply protection.
Connections to a potable water supply shall be protected against backflow in accordance with this Code.

10.4.11.1.4 Secondary water supply.
Where a secondary water supply is required for an automatic sprinkler system, an automatic
water mist system shall be provided with an approved secondary water supply.

10.4.11.2 Water mist system supervision and alarms.

Supervision and alarms shall be provided as required for automatic sprinkler systems in accordance with Clause 10.3.4.

10.4.11.2.1 Monitoring.

Monitoring shall be provided as required for automatic sprinkler systems in accordance with Clause 10.3.4.1.

10.4.11.2.2 Alarms.

Alarms shall be provided as required for automatic sprinkler systems in accordance with Clause 10.3.4.2.

10.4.11.2.3 Floor control valves.

Floor control valves shall be provided as required for automatic sprinkler systems in accordance with Clause 10.3.4.3.

10.4.11.3 Testing and maintenance.

Automatic water mist systems shall be tested and maintained in accordance with the Ghana Fire Code.

10.4.12 Commercial cooking systems.

The automatic fire-extinguishing system for commercial cooking systems shall be of a type recognized for protection of commercial cooking equipment and exhaust systems of the type and arrangement protected. Preengineered automatic dry- and wet-chemical extinguishing systems shall be tested in accordance with this Code and listed and labelled for the intended application. Other types of automatic fire-extinguishing systems shall be listed and labelled for specific use as protection for commercial cooking operations. The system shall be installed in accordance with this Code, the Ghana Fire Code, its listing and the manufacturer’s installation instructions. Automatic fire-extinguishing systems of the following types shall be installed in accordance with the referenced standard indicated, as follows:

1. Carbon dioxide extinguishing systems, the Ghana Fire Code

2. Automatic sprinkler systems, the Ghana Fire Code.

3. Automatic water mist systems, the Ghana Fire Code.

4. Foam-water sprinkler system or foam-water spray systems, the Ghana Fire Code.

5. Dry-chemical extinguishing systems, the Ghana Fire Code.

6. Wet-chemical extinguishing systems, the Ghana Fire Code.

Exception: Factory-built commercial cooking recirculating systems that are tested in accordance with this Code and listed, labeled and installed in accordance with this Code.

10.4.12.1 Manual system operation.

A manual actuation device shall be located at or near a means of Escape from the cooking area not less than 3048 mm (10 feet) and not more than 6096 mm (20 feet) from the kitchen exhaust system. The manual actuation device shall be installed not more than 48 inches (1200 mm) or less than 1067 mm (42 inches) above the floor and shall clearly identify the hazard protected. The manual actuation shall require a maximum force of 178 N (40 pounds) and a maximum movement of 356 mm (14 inches) to actuate the fire suppression system.

Exception: Automatic sprinkler systems shall not be required to be equipped with manual actuation means.

10.4.12.2 System interconnection.

The actuation of the fire suppression system shall automatically shut down the fuel or electrical power supply to the cooking equipment. The fuel and electrical supply reset shall be manual.

10.4.12.3 Carbon dioxide systems.

Where carbon dioxide systems are used, there shall be a nozzle at the top of the ventilating duct. Additional nozzles that are symmetrically arranged to give uniform distribution shall be installed within vertical ducts exceeding 20 feet (6096 mm) and horizontal ducts exceeding 15 240 mm (50 feet). Dampers shall be installed at either the top or the bottom of the duct and shall be arranged to operate automatically upon activation of the fire-extinguishing system. Where the damper is installed at the top of the...
duct, the top nozzle shall be immediately below the damper. Automatic carbon dioxide fire-extinguishing systems shall be sufficiently sized to protect against all hazards venting through a common duct simultaneously.

10.4.12.3.1 Ventilation system.

Commercial-type cooking equipment protected by an automatic carbon dioxide-extinguishing system shall be arranged to shut off the ventilation system upon activation.

10.4.12.4 Special provisions for automatic sprinkler systems.

Automatic sprinkler systems protecting commercial-type cooking equipment shall be supplied from a separate, indicating-type control valve that is identified. Access to the control valve shall be provided.

10.4.12.4.1 Listed sprinklers.

Sprinklers used for the protection of fryers shall be tested in accordance with this Code, listed for that application and installed in accordance with their listing.

10.4.13 Domestic cooking systems.

Cooktops and ranges installed in the following occupancies shall be protected in accordance with Clause 10.4.13.1:

1. In Group I-1 occupancies where domestic cooking facilities are installed in accordance with Clause 4.20.8.

2. In Group I-2, Condition 1 occupancies where domestic cooking facilities are installed in accordance with Clause 4.7.2.6.

3. In Group R-2 college dormitories where domestic cooking facilities are installed in accordance with this Code.

10.4.13.1 Protection from fire.

Cooktops and ranges shall be protected in accordance with Clause 10.4.13.1.1 or 10.4.13.1.2.

10.4.13.1.1 Automatic fire-extinguishing system.

The domestic recirculating or exterior vented cooking hood provided over the cooktop or range shall be equipped with an approved automatic fire-extinguishing system complying with the following:

1. The automatic fire-extinguishing system shall be of a type recognized for protection of domestic cooking equipment. Preengineered automatic fire-extinguishing systems shall be listed and labelled in accordance with this Code and installed in accordance with the manufacturer's instructions.

2. Manual actuation of the fire-extinguishing system shall be provided in accordance with Clause 10.4.12.1.

3. Interconnection of the fuel and electric power supply shall be in accordance with Clause 10.4.12.2.

10.4.13.1.2 Ignition prevention.

Cooktops and ranges shall include burners that have been tested and listed to prevent ignition of cooking oil with burners turned on to their maximum heat settings and allowed to operate for 30 minutes.

10.4.14 Aerosol fire-extinguishing systems.

Aerosol fire-extinguishing systems shall be installed, periodically inspected, tested and maintained in accordance with Clauses 10.1 and 10.4.4, the Ghana Fire Code and in accordance with their listing.

Such devices and appurtenances shall be listed and installed in compliance with manufacturer's instructions.

10.5 FIRE HYDRANT SYSTEMS

10.5.1 General.

Fire hydrant systems shall be provided in new buildings and structures in accordance with Clauses 10.5.2 through 10.5.11. In buildings used for high-piled combustible storage, fire protection shall be in accordance with the Ghana Fire Code.

10.5.2 Installation standard.

Fire hydrant systems shall be installed in
accordance with this clause and the Ghana Fire Code. Fire department connections for Fire hydrant systems shall be in accordance with Clause 10.12.

10.5.3 Required installations.
Fire hydrant systems shall be installed where required by Clauses 10.5.3.1 through 10.5.3.8. Fire hydrant systems are allowed to be combined with automatic sprinkler systems.

Exception:
Fire hydrant systems are not required in Group R-3 occupancies.

10.5.3.1 Height.
Class III Fire hydrant systems shall be installed throughout buildings where any of the following conditions exist:

1. Four or more stories are above or below grade plane.
2. The floor level of the highest storey is located more than 9144 mm (30 feet) above the lowest level of fire department vehicle access.
3. The floor level of the lowest storey is located more than 9144 mm (30 feet) below the highest level of fire department vehicle access.

Exceptions:
1. Class I standpipes are allowed in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.
2. Class I standpipes are allowed in Group B and E occupancies.
3. Class I manual standpipes are allowed in open parking garages where the highest floor is located not more than 45 720 mm (150 feet) above the lowest level of fire department vehicle access.
4. Class I manual dry standpipes are allowed in open parking garages that are subject to freezing temperatures, provided that the hose connections are located as required for Class II standpipes in accordance with Clause 10.5.5.
5. Class I standpipes are allowed in basements equipped throughout with an automatic sprinkler system.
6. Class I standpipes are allowed in buildings where occupant-use hose lines will not be utilized by trained personnel or the fire department.
7. In determining the lowest level of fire department vehicle access, it shall not be required to consider either of the following:
   7.1. Recessed loading docks for four vehicles or less.
   7.2. Conditions where topography makes access from the fire department vehicle to the building impractical or impossible.

10.5.3.2 Group A.
Class I automatic wet standpipes shall be provided in nonsprinklered Group A buildings having an occupant load exceeding 1,000 persons.

Exceptions:
1. Open-air-seating spaces without enclosed spaces.
2. Class I automatic dry and semiautomatic dry standpipes or manual wet standpipes are allowed in buildings that are not high-rise buildings.

10.5.3.3 Covered and open mall buildings.
Covered mall and open mall buildings shall be equipped throughout with a Fire hydrant system where required by clause 10.5.3.1. Mall buildings not required to be equipped with a Fire hydrant system by clause 10.5.3.1 shall be equipped with class I hose connections connected to the automatic sprinkler system sized to deliver water at 250 gallons per minute (946.4 l/min) at the hydraulically most remote...
hose connection while concurrently supplying the automatic sprinkler system demand. The Fire hydrantsystem shall be designed to not exceed a 345 kpa (50 pounds per square inch (psi)) residual pressure loss with a flow of 250 gallons per minute (946.4 l/min) from the fire department connection to the hydraulically most remote hose connection. Hose connections shall be provided at each of the following locations:

1. within the mall at the entrance to each exit passageway or corridor.
2. At each floor-level landing within interior exit stairways opening directly on the mall.
3. At exterior public entrances to the mall of a covered mall building.
4. At public entrances at the perimeter line of an open mall building.
5. At other locations as necessary so that the distance to reach all portions of a tenant space does not exceed 60 960 mm (200 feet) from a hose connection.

10.5.3.4 Stages.
Stages greater than 93 m² (1,000 square feet in area) shall be equipped with a Class III wet Fire hydrant system with 38 mm and 64 mm (1 1/2- and 2 1/2-inch) hose connections on each side of the stage.

Exception: Where the building or area is equipped throughout with an automatic sprinkler system, a 38 mm (1 1/2-inch) hose connection shall be installed in accordance with the Ghana Fire Code.

10.5.3.4.1 Hose and cabinet.
The 38 mm (1 1/2-inch) hose connections shall be equipped with sufficient lengths of 38 mm (1 1/2-inch) hose to provide fire protection for the stage area. Hose connections shall be equipped with an approved adjustable fog nozzle and be mounted in a cabinet or on a rack.

10.5.3.5 Underground buildings.
Underground buildings shall be equipped throughout with a Class I automatic wet or manual wet Fire hydrant system.

10.5.3.6 Helistops and heliports.
Buildings with a rooftop helistop or heliport shall be equipped with a Class I or III Fire hydrant system extended to the roof level on which the helistop or heliport is located in accordance with the Ghana Fire Code.

10.5.3.7 Marinas and boatyards.
Standpipes in marinas and boatyards shall comply with the Ghana Fire Code.

10.5.3.8 Rooftop gardens and landscaped roofs.
Buildings or structures that have rooftop gardens or landscaped roofs and that are equipped with a Fire hydrant system shall have the Fire hydrant system extended to the roof level on which the rooftop garden or landscaped roof is located.

10.5.4 Location of Class I Fire hydrant hose connections.
Class I Fire hydrant hose connections shall be provided in all of the following locations:

1. In every required interior exit stairway, a hose connection shall be provided for each storey above and below grade plane. Hose connections shall be located at the main floor landing unless otherwise approved by the fire Code official.

   Exception: A single hose connection shall be permitted to be installed in the open corridor or open breezeway between open stairs that are not greater than 22 860 mm (75 feet) apart.

2. On each side of the wall adjacent to the exit opening of a horizontal exit.

   Exception: Where floor areas adjacent to a horizontal exit are reachable from an interior exit stairway hose connection by a 9144 mm (30-foot) hose stream from a nozzle attached to 30 480 mm (100 feet) of hose, a hose connection shall not be required at the horizontal exit.
3. In every exit passageway, at the entrance from the exit passageway to other areas of a building.

**Exception:** Where floor areas adjacent to an exit passageway are reachable from an interior exit stairway hose connection by a 9144 mm (30-foot) hose stream from a nozzle attached to 30 480 mm (100 feet) of hose, a hose connection shall not be required at the entrance from the exit passageway to other areas of the building.

4. In covered mall buildings, adjacent to each exterior public entrance to the mall and adjacent to each entrance from an exit passageway or exit corridor to the mall. In open mall buildings, adjacent to each public entrance to the mall at the perimeter line and adjacent to each entrance from an exit passageway or exit corridor to the mall.

5. Where the roof has a slope less than four units vertical in 12 units horizontal (33.3-percent slope), a hose connection shall be located to serve the roof or at the highest landing of an interior exit stairway with access to the roof provided in accordance with Clause 11.11.12.

6. Where the most remote portion of a nonsprinklered floor or storey is more than 45 720 mm (150 feet) from a hose connection or the most remote portion of a sprinklered floor or storey is more than 60 960 mm (200 feet) from a hose connection, the fire Code official is authorized to require that additional hose connections be provided in approved locations.

**10.5.4.1 Protection.**
Risers and laterals of Class I Fire hydrant systems not located within an interior exit stairway shall be protected by a degree of fire resistance equal to that required for vertical enclosures in the building in which they are located.

**Exception:** In buildings equipped throughout with an approved automatic sprinkler system, laterals that are not located within an interior exit stairway are not required to be enclosed within fire-resistance-rated construction.

**10.5.4.2 Interconnection.**
In buildings where more than one Fire hydrant provided, the standpipes shall be interconnected in accordance with the Ghana Fire Code.

**10.5.5 Location of Class II Fire hydrant hose connections.**
Class II Fire hydrant hose connections located so that all portions of the building are within 9144 mm (30 feet) of a nozzle attached to 30 480 mm (100 feet) of hose. Class II Fire hydrant hose connections shall be located where they will have ready access.

**10.5.5.1 Groups A-1 and A-2.**
In Group A-1 and A-2 occupancies having occupant loads exceeding 1,000 persons, hose connections shall be located on each side of any stage, on each side of the rear of the auditorium, on each side of the balcony and on each tier of dressing rooms.

**10.5.5.2 Protection.**
Fire-resistance-rated protection of risers and laterals of Class II Fire hydrant systems is not required.

**10.5.5.3 Class II system 1-inch hose.**
A minimum 25 mm (1-inch) hose shall be allowed to be used for hose stations in light-hazard occupancies where investigated and listed for this service and where approved by the fire Code official.

**10.5.6 Location of Class III Fire hydrant hose connections.**
Class III Fire hydrant systems shall have hose connections located as required for Class I standpipes in Clause 10.5.4 and shall have Class II hose connections as required in Clause 10.5.5.

**10.5.6.1 Protection.**
Risers and laterals of Class III Fire hydrant systems shall be protected as required for Class I systems in accordance with Clause 10.5.4.1.

**10.5.6.2 Interconnection.**
In buildings where more than one Class III Fire hydrant provided, the standpipes shall be interconnected in accordance with the Ghana Fire Code.

**10.5.7 Cabinets.**
Cabinets containing fire-fighting equipment such as standpipes, fire hoses, fire extinguishers or fire department valves shall not be blocked from use or obscured from view.
10.5.7.1 Cabinet equipment identification. Cabinets shall be identified in an approved manner by a permanently attached sign with letters not less than 51 mm (2 inches) high in a color that contrasts with the background color, indicating the equipment contained therein.

Exceptions:
1. Doors not large enough to accommodate a written sign shall be marked with a permanently attached pictogram of the equipment contained therein.
2. Doors that have either an approved visual identification clear glass panel or a complete glass door panel are not required to be marked.

10.5.7.2 Locking cabinet doors. Cabinets shall be unlocked.

Exceptions:
1. Visual identification panels of glass or other approved transparent frangible material that is easily broken and allows access.
2. Approved locking arrangements.
3. Group I-3 occupancies.

10.5.8 Dry standpipes. Dry standpipes shall not be installed.

Exception: Where subject to freezing and in accordance with the Ghana Fire Code

10.5.9 Valve supervision. Valves controlling water supplies shall be supervised in the open position so that a change in the normal position of the valve will generate a supervisory signal at the supervising station required by Clause 10.3.4. Where a fire alarm system is provided, a signal shall be transmitted to the control unit.

Exceptions:
1. Valves to underground key or hub valves in roadway boxes provided by the municipality or public utility do not require supervision.
2. Valves locked in the normal position and inspected as provided in this Code in buildings not equipped with a fire alarm system.

10.5.10 During construction. Fire hydrant systems required during construction and demolition operations shall be provided in accordance with Clause 3311.

10.5.11 Locking Fire hydrant outlet caps. The fire Code official is authorized to require locking caps on the outlets on dry standpipes where the responding fire department carries key wrenches for the removal that are compatible with locking FDC connection caps.

10.6 PORTABLE FIRE EXTINGUISHERS

10.6.1 Where required. Portable fire extinguishers shall be installed in all of the following locations:

1. In Group A, B, E, F, H, I, M, R-1, R-2, R-4 and S occupancies.

Exceptions:
1. In Group R-2 occupancies, portable fire extinguishers shall be required only in locations specified in Items 2 through 6 where each dwelling unit is provided with a portable fire extinguisher having a minimum rating of 1-A:10-B:C.
2. In Group E occupancies, portable fire extinguishers shall be required only in locations specified in Items 2 through 6 where each classroom is provided with a portable fire extinguisher having a minimum rating of 2-A:20-B:C.
2. Within 9144 mm (30 feet) distance of travel from commercial cooking equipment and from domestic cooking equipment in Group I-1; I-2, Condition 1; and R-2 college dormitory occupancies.
3. In areas where flammable or combustible liquids are stored, used or dispensed.
4. On each floor of structures under construction, except Group R-3
occupancies, in accordance with the Ghana Fire Code.

5. Where required by the Ghana Fire Code clauses indicated in Table 10.6.1.

6. Special-hazard areas, including but not limited to laboratories, computer rooms and generator rooms, where required by the fire Code official.

### TABLE 10.6.1 ADDITIONAL REQUIRED PORTABLE FIRE EXTINGUISHERS IN THE GHANA FIRE CODE

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>LIGHT (Low) HAZARD OCCUPANCY</th>
<th>ORDINARY (Moderate) HAZARD OCCUPANCY</th>
<th>EXTRA (High) HAZARD OCCUPANCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt kettles</td>
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<tr>
<td>Open burning</td>
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<td>Open flames—torches</td>
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<td>Powered industrial trucks</td>
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<tr>
<td>Aircraft towing vehicles</td>
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<tr>
<td>Aircraft welding apparatus</td>
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<tr>
<td>Aircraft fuel-servicing tank vehicles</td>
<td></td>
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<td></td>
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<tr>
<td>Aircraft hydrant fuel-servicing vehicles</td>
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<tr>
<td>Aircraft fuel-dispensing stations</td>
<td></td>
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<tr>
<td>Helisports and helistops</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dry cleaning plants</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Motor fuel-dispensing facilities</td>
<td></td>
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<tr>
<td>Marine motor fuel-dispensing facilities</td>
<td></td>
<td></td>
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<tr>
<td>Repair garages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray-finishing operations</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dip-tank operations</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Powder-coating areas</td>
<td></td>
<td></td>
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<tr>
<td>Timberyards/woodworking facilities</td>
<td></td>
<td></td>
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<tr>
<td>Recycling facilities</td>
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<tr>
<td>Exterior timber storage</td>
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<td></td>
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<tr>
<td>Organic-coating areas</td>
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<tr>
<td>Industrial ovens</td>
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<tr>
<td>Tents and membrane structures</td>
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<tr>
<td>High-piled storage</td>
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<tr>
<td>Buildings under construction or demolition</td>
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<tr>
<td>Roofing operations</td>
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<tr>
<td>Tire rebuilding/storage</td>
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<tr>
<td>Welding and other hot work</td>
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<tr>
<td>Marinas</td>
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<tr>
<td>Combustible fibers</td>
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<tr>
<td>Flammable and combustible liquids, general</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Indoor storage of flammable and combustible liquids</td>
<td></td>
<td></td>
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<tr>
<td>Liquid storage rooms for flammable and combustible liquids</td>
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<tr>
<td>Solvent distillation units</td>
<td></td>
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<td></td>
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<tr>
<td>Farms and construction sites—flammable and combustible liquids storage</td>
<td></td>
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<td></td>
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<tr>
<td>Bulk plants and terminals for flammable and combustible liquids</td>
<td></td>
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<tr>
<td>Commercial, industrial, governmental or manufacturing establishments—fuel dispensing</td>
<td></td>
<td></td>
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<tr>
<td>Tank vehicles for flammable and combustible liquids</td>
<td></td>
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<tr>
<td>Flammable solids</td>
<td></td>
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<tr>
<td>LP-gas</td>
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<td></td>
<td></td>
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</tbody>
</table>

### 10.6.2 General requirements.
Portable fire extinguishers shall be selected and installed in accordance with this clause and the Ghana Fire Code.

**Exceptions:**

1. The distance of travel to reach an extinguisher shall not apply to the spectator seating portions of Group A-5 occupancies.

2. In Group I-3, portable fire extinguishers shall be permitted to be located at staff locations.

### 10.6.3 Size and distribution.
The size and distribution of portable fire extinguishers shall be in accordance with Clauses 10.6.3.1 through 10.6.3.4

### TABLE 10.6.3(1) FIRE EXTINGUISHERS FOR CLASS A FIRE HAZARDS

<table>
<thead>
<tr>
<th>Minimum-rated single extinguisher</th>
<th>LIGHT (Low) HAZARD OCCUPANCY</th>
<th>ORDINARY (Moderate) HAZARD OCCUPANCY</th>
<th>EXTRA (High) HAZARD OCCUPANCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-A</td>
<td>2-A</td>
<td>4-A&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Maximum floor area per unit of A</td>
<td>3,000 square feet</td>
<td>1,500 square feet</td>
<td>1,000 square feet</td>
</tr>
<tr>
<td>Maximum floor area for extinguisher&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11,250 square feet</td>
<td>11,250 square feet</td>
<td>11,250 square feet</td>
</tr>
<tr>
<td>Maximum distance of travel to extinguisher</td>
<td>75 feet</td>
<td>75 feet</td>
<td>75 feet</td>
</tr>
</tbody>
</table>

Note: For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1 gallon = 3.785 L.
a. Two 2 1/2-gallon water-type extinguishers shall be deemed the equivalent of one 4-A rated extinguisher.

b. Annex E.3.3 of the Ghana Fire Code provides more details concerning application of the maximum floor area criteria.

c. Two water-type extinguishers each with a 1-A rating shall be deemed the equivalent of one 2-A rated extinguisher for Light (Low) Hazard Occupancies

### TABLE 10.6.3(2) FIRE EXTINGUISHERS FOR FLAMMABLE OR COMBUSTIBLE LIQUIDS WITH DEPTHS LESS THAN OR EQUAL TO 0.25 INCH

<table>
<thead>
<tr>
<th>TYPE OF HAZARD</th>
<th>BASIC MINIMUM EXTINGUISHER RATING</th>
<th>MAXIMUM DISTANCE OF TRAVEL TO EXTINGUISHERS (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light (Low)</td>
<td>5-B</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10-B</td>
<td>50</td>
</tr>
<tr>
<td>Ordinary (Moderate)</td>
<td>10-B</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>20-B</td>
<td>50</td>
</tr>
<tr>
<td>Extra (High)</td>
<td>40-B</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>80-B</td>
<td>50</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. For requirements on water-soluble flammable liquids and alternative sizing criteria, see Clause 5.5 of NFPA 10.

### 10.6.3.1 Class A fire hazards.
The minimum sizes and distribution of portable fire extinguishers for occupancies that involve primarily Class A fire hazards shall comply with Table 10.6.3(1).

### 10.6.3.2 Class B fire hazards.
Portable fire extinguishers for occupancies involving flammable or combustible liquids with depths less than or equal to 6.4 mm (0.25-inch) shall be selected and placed in accordance with Table 10.6.3(2).

Portable fire extinguishers for occupancies involving flammable or combustible liquids with a depth of greater than 6.4 mm (0.25-inch) shall be selected and placed in accordance with the Ghana Fire Code.

### 10.6.3.3 Class C fire hazards.
Portable fire extinguishers for Class C fire hazards shall be selected and placed on the basis of the anticipated Class A or B hazard.

### 10.6.3.4 Class D fire hazards.
Portable fire extinguishers for occupancies involving combustible metals shall be selected and placed in accordance with the Ghana Fire Code.

### 10.6.4 Cooking equipment fires.
Fire extinguishers provided for the protection of cooking equipment shall be of an approved type compatible with the automatic fire-extinguishing system agent. Cooking equipment involving solid fuels or vegetable or animal oils and fats shall be protected by a Class K-rated portable extinguisher in accordance with Clauses 10.6.1, Item 2, 10.6.4.1 and 10.6.4.2 of the Ghana Fire Code, as applicable.

### 10.6.5 Conspicuous location.
Portable fire extinguishers shall be located in conspicuous locations where they will have ready access and be immediately available for use. These locations shall be along normal paths of travel, unless the fire Code official determines that the hazard posed indicates the need for placement away from normal paths of travel.

### 10.6.6 Unobstructed and unobscured.
Portable fire extinguishers shall not be obstructed or obscured from view. In rooms or areas in which visual obstruction cannot be completely avoided, means shall be provided to indicate the locations of extinguishers.

### 10.6.7 Hangers and brackets.
Hand-held portable fire extinguishers, not housed in cabinets, shall be installed on the hangers or brackets supplied. Hangers or brackets shall be securely anchored to the mounting surface in accordance with the manufacturer’s installation instructions.

### 10.6.8 Cabinets.
Cabinets used to house portable fire extinguishers shall not be locked.

**Exceptions:**

1. Where portable fire extinguishers subject to malicious use or damage
are provided with a means of ready access.

2. In Group I-3 occupancies and in mental health areas in Group I-2 occupancies, access to portable fire extinguishers shall be permitted to be locked or to be located in staff locations provided that the staff has keys.

10.6.9 Extinguisher installation.
The installation of portable fire extinguishers shall be in accordance with Clauses 10.6.9.1 through 10.6.9.3.

10.6.9.1 Extinguishers weighing 40 pounds or less.
Portable fire extinguishers having a gross weight not exceeding 18 kg (40 pounds) shall be installed so that their tops are not more than 1524 mm (5 feet) above the floor.

10.6.9.2 Extinguishers weighing more than 40 pounds.
Hand-held portable fire extinguishers having a gross weight exceeding 18 kg (40 pounds) shall be installed so that their tops are not more than 1067 mm (3.5 feet) above the floor.

10.6.9.3 Floor clearance.
The clearance between the floor and the bottom of installed hand-held portable fire extinguishers shall be not less than 102 mm (4 inches).

10.6.10 Wheeled units.
Wheeled fire extinguishers shall be conspicuously located in a designated location.

10.7 FIRE ALARM AND DETECTION SYSTEMS

10.7.1 General.
This clause covers the application, installation, performance and maintenance of fire alarm systems and their components.

10.7.1.1 Construction documents.
Construction documents for fire alarm systems shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this Code, the Ghana Fire Code and relevant IEN 310, rules and regulations, as determined by the fire Code official.

10.7.1.2 Fire alarm shop drawings.
Fire plan and shop drawings for fire alarm systems shall be prepared in accordance with ISO 7240 and submitted for review and approval prior to system installation.

10.7.1.3 Equipment.
Systems and components shall be listed and approved for the purpose for which they are installed.

10.7.2 Where required—new buildings and structures.
An approved fire alarm system installed in accordance with the provisions of this Code and ISO 7240 shall be provided in new buildings and structures in accordance with Clauses 10.7.2.1 through 10.7.2.23 and provide occupant notification in accordance with Clause 10.7.5, unless other requirements are provided by another clause of this Code.

Not less than one manual fire alarm box shall be provided in an approved location to initiate a fire alarm signal for fire alarm systems employing automatic fire detectors or waterflow detection devices. Where other clauses of this Code allow elimination of fire alarm boxes due to sprinklers, a single fire alarm box shall be installed.

Exceptions:

1. The manual fire alarm box is not required for fire alarm systems dedicated to elevator recall control and supervisory service.

2. The manual fire alarm box is not required for Group R-2 occupancies unless required by the fire Code official to provide a means for fire watch personnel to initiate an alarm during a sprinkler system impairment event. Where provided, the manual fire alarm box shall not be located in an area that is open to the public.

10.7.2.1 Group A.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group A occupancies where the occupant load due to the assembly occupancy is 300 or more, or where the Group A occupant load is more than
100 persons above or below the lowest level of exit discharge. Group A occupancies not separated from one another in accordance with Clause 8.7.3.10 shall be considered as a single occupancy for the purposes of applying this clause. Portions of Group E occupancies occupied for assembly purposes shall be provided with a fire alarm system as required for the Group E occupancy.

Exception: Manual fire alarm boxes are not required where the building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 and the occupant notification appliances will activate throughout the notification zones upon sprinkler water flow.

10.7.2.1 System initiation in Group A occupancies with an occupant load of 1,000 or more.
Activation of the fire alarm in Group A occupancies with an occupant load of 1,000 or more shall initiate a signal using an emergency voice/alarm communications system in accordance with Clause 10.7.5.2.2.

Exception: Where approved, the prerecorded announcement is allowed to be manually deactivated for a period of time, not to exceed 3 minutes, for the sole purpose of allowing a live voice announcement from an approved, constantly attended location.

10.7.2.2 Group B.
A manual fire alarm system shall be installed in Group B occupancies where one of the following conditions exists:

1. The combined Group B occupant load of all floors is 500 or more.
2. The Group B occupant load is more than 100 persons above or below the lowest level of exit discharge.
3. The fire area contains an ambulatory care facility.

Exception: Manual fire alarm boxes are not required where the building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 and the occupant notification appliances will activate throughout the notification zones upon sprinkler water flow.

10.7.2.2.1 Ambulatory care facilities.
Fire areas containing ambulatory care facilities shall be provided with an electronically supervised automatic smoke detection system installed within the ambulatory care facility and in public use areas outside of tenant spaces, including public corridors and elevator lobbies.

Exception: Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, provided that the occupant notification appliances will activate throughout the notification zones upon sprinkler waterflow.

10.7.2.3 Group E.
A manual fire alarm system that initiates the occupant notification signal utilizing an emergency voice/alarm communication system meeting the requirements of Clause 10.7.5.2.2 and installed in accordance with Clause 10.7.6 shall be installed in Group E occupancies. Where automatic sprinkler systems or smoke detectors are installed, such systems or detectors shall be connected to the building fire alarm system.

Exceptions:

1. A manual fire alarm system is not required in Group E occupancies with an occupant load of 50 or less.
2. Emergency voice/alarm communication systems meeting the requirements of Clause 10.7.5.2.2 and installed in accordance with Clause 10.7.6 shall not be required in Group E occupancies with occupant loads of 100 or less, provided that activation of the manual fire alarm system initiates an approved occupant notification signal in accordance with Clause 10.7.5.
3. Manual fire alarm boxes are not required in Group E occupancies where all of the following apply:
3.1. Interior corridors are protected by smoke detectors.

3.2. Auditoriums, cafeterias, gymnasiums and similar areas are protected by heat detectors or other approved detection devices.

3.3. Shops and laboratories involving dusts or vapours are protected by heat detectors or other approved detection devices.

4. Manual fire alarm boxes shall not be required in Group E occupancies where all of the following apply:

4.1. The building is equipped throughout with an approved automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.

4.2. The emergency voice/alarm communication system will activate on sprinkler waterflow.

4.3. Manual activation is provided from a normally occupied location.

10.7.2.4 Group F.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group F occupancies where both of the following conditions exist:

1. The Group F occupancy is two or more stories in height.

2. The Group F occupancy has a combined occupant load of 500 or more above or below the lowest level of exit discharge.

Exception: Manual fire alarm boxes are not required where the building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 and the occupant notification appliances will activate throughout the notification zones upon sprinkler water flow.

10.7.2.5 Group H.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group H-5 occupancies and in occupancies used for the manufacture of organic coatings. An automatic smoke detection system shall be installed for highly toxic gases, organic peroxides and oxidizers in accordance with Parts 60, 62 and 63, respectively, of the Ghana Fire Code.

10.7.2.6 Group I.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group I-5 occupancies and in occupancies used for the manufacture of organic coatings. An automatic smoke detection system that activates the occupant notification system in accordance with Clause 907.5 shall be provided in accordance with Clauses 10.7.2.6.1, 10.7.2.6.2 and 10.7.2.6.3.3.

Exceptions:

1. Manual fire alarm boxes in sleeping units of Group I-1 and I-2 occupancies shall not be required at exits if located at all care providers’ control stations or other constantly attended staff locations, provided that such manual fire alarm boxes are visible and provided with ready access, and the distances of travel required in Clause 10.7.4.2.1 are not exceeded.

2. Occupant notification systems are not required to be activated where private mode signaling installed in accordance with ISO 7240 is approved by the fire Code official and staff evacuation responsibilities are included in the fire safety and evacuation plan required by the Ghana Fire Code.
10.7.2.6.1 Group I-1.
In Group I-1 occupancies, an automatic smoke detection system shall be installed in corridors, waiting areas open to corridors and habitable spaces other than sleeping units and kitchens. The system shall be activated in accordance with Clause 10.7.5.

Exceptions:

1. For Group I-1, Condition 1 occupancies, smoke detection in habitable spaces is not required where the facility is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.

2. Smoke detection is not required for exterior balconies.

10.7.2.6.1.1 Smoke alarms.
Single- and multiple-station smoke alarms shall be installed in accordance with Clause 10.7.2.11.

10.7.2.6.2 Group I-2.
An automatic smoke detection system shall be installed in corridors in Group I-2, Condition 1 facilities and spaces permitted to be open to the corridors by Clause 407.2. The system shall be activated in accordance with Clause 10.7.4. Group I-2, Condition 2 occupancies shall be equipped with an automatic smoke detection system as required in Clause 407.

Exceptions:

1. Corridor smoke detection is not required in smoke compartments that contain sleeping units where sleeping unit doors are equipped with automatic door-closing devices with integral smoke detectors on the unit sides installed in accordance with their listing, provided that the integral detectors perform the required alerting function.

10.7.2.6.3 Group I-3 occupancies.
Group I-3 occupancies shall be equipped with a manual fire alarm system and automatic smoke detection system installed for alerting staff.

10.7.2.6.3.1 System initiation.
Actuation of an automatic fire-extinguishing system, automatic sprinkler system, a manual fire alarm box or a fire detector shall initiate an approved fire alarm signal that automatically notifies staff.

10.7.2.6.3.2 Manual fire alarm boxes.
Manual fire alarm boxes are not required to be located in accordance with Clause 10.7.4.2 where the fire alarm boxes are provided at staff-attended locations having direct supervision over areas where manual fire alarm boxes have been omitted.

10.7.2.6.3.2.1 Manual fire alarm boxes in detainee areas.
Manual fire alarm boxes are allowed to be locked in areas occupied by detainees, provided that staff members are present within the subject area and have keys readily available to operate the manual fire alarm boxes.

10.7.2.6.3.3 Automatic smoke detection system.
An automatic smoke detection system shall be installed throughout resident housing areas, including sleeping units and contiguous day rooms, group activity spaces and other common spaces normally open to residents.

Exceptions:

1. Other approved smoke detection arrangements providing equivalent protection, including, but not limited to, placing detectors in exhaust ducts from
cells or behind protective guards listed for the purpose, are allowed where necessary to prevent damage or tampering.

2. Sleeping units in Use Conditions 2 and 3 as described in this Code.

3. Smoke detectors are not required in sleeping units with four or fewer occupants in smoke compartments that are equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.

### 10.7.2.7 Group M.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group M occupancies where one of the following conditions exists:

1. The combined Group M occupant load of all floors is 500 or more persons.

2. The Group M occupant load is more than 100 persons above or below the lowest level of exit discharge.

**Exceptions:**

1. A manual fire alarm system is not required in covered or open mall buildings complying with Clause 4.2.

2. Manual fire alarm boxes are not required where the building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 and the occupant notification appliances will automatically activate throughout the notification zones upon sprinkler water flow.

### 10.7.2.7.1 Occupant notification.
During times that the building is occupied, the initiation of a signal from a manual fire alarm box or from a water flow switch shall not be required to activate the alarm notification appliances when an alarm signal is activated at a constantly attended location from which evacuation instructions shall be initiated over an emergency voice/alarm communication system installed in accordance with Clause 10.7.5.2.2.

### 10.7.2.8 Group R-1.
Fire alarm systems and smoke alarms shall be installed in Group R-1 occupancies as required in Clauses 10.7.2.8.1 through 10.7.2.8.3.

#### 10.7.2.8.1 Manual fire alarm system.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group R-1 occupancies.

**Exceptions:**

1. A manual fire alarm system is not required in buildings not more than two stories in height where all individual sleeping units and contiguous attic and crawl spaces to those units are separated from each other and public or common areas by not less than 1-hour fire partitions and each individual sleeping unit has an exit directly to a public way, escape court or yard.

2. Manual fire alarm boxes are not required throughout the building where all of the following conditions are met:

   2.1. The building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

   2.2. The notification appliances will activate upon sprinkler water flow.
2.3. Not less than one manual fire alarm box is installed at an approved location.

10.7.2.8.2 Automatic smoke detection system.
An automatic smoke detection system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed throughout all interior corridors serving sleeping units.

Exception: An automatic smoke detection system is not required in buildings that do not have interior corridors serving sleeping units and where each sleeping unit has a means of Escape door opening directly to an exit or to an exterior exit access that leads directly to an exit.

10.7.2.8.3 Smoke alarms.
Single- and multiple-station smoke alarms shall be installed in accordance with Clause 10.7.2.10.

10.7.2.9 Group R-2.
Fire alarm systems and smoke alarms shall be installed in Group R-2 occupancies as required in Clauses 10.7.2.9.1 through 10.7.2.9.3.

10.7.2.9.1 Manual fire alarm system.
A manual fire alarm system that activates the occupant notification system in accordance with Clause 907.5 shall be installed in Group R-2 occupancies where any of the following conditions apply:

1. Any dwelling unit or sleeping unit is located three or more stories above the lowest level of exit discharge.
2. Any dwelling unit or sleeping unit is located more than one storey below the highest level of exit discharge of exits serving the dwelling unit or sleeping unit.
3. The building contains more than 16 dwelling units or sleeping units.

Exceptions:

1. A fire alarm system is not required in buildings not more than two stories in height where all dwelling units or sleeping units and contiguous attic and crawl spaces are separated from each other and public or common areas by not less than 1-hour fire partitions and each dwelling unit or sleeping unit has an exit directly to a public way, Escape court or yard.

2. Manual fire alarm boxes are not required where the building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and the occupant notification appliances will automatically activate throughout the notification zones upon a sprinkler water flow.

3. A fire alarm system is not required in buildings that do not have interior corridors serving dwelling units and are protected by an approved automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, provided that dwelling units either have a means of Escape door opening directly to an exterior exit access that leads directly to the exits or are served by open-ended corridors designed in accordance with Clause 11.27.6, Exception 3.

10.7.2.9.2 Smoke alarms.
Single- and multiple-station smoke alarms shall be installed in accordance with Clause 10.7.2.10.

10.7.2.9.3 Group R-2 college and university buildings.
An automatic smoke detection system that activates the occupant notification system in accordance with Clause 10.7.5 shall be installed in Group R-2 occupancies operated by a college or university for student or staff housing in all of the following locations:
1. Common spaces outside of dwelling units and sleeping units.
2. Laundry rooms, mechanical equipment rooms and storage rooms.
3. All interior corridors serving sleeping units or dwelling units.

Exception: An automatic smoke detection system is not required in buildings that do not have interior corridors serving sleeping units or dwelling units and where each sleeping unit or dwelling unit either has a means of escape door opening directly to an exterior exit access that leads directly to an exit or a means of Escape door opening directly to an exit.

Required smoke alarms in dwelling units and sleeping units in Group R-2 occupancies operated by a college or university for student or staff housing shall be interconnected with the fire alarm system in accordance with ISO 7240.

10.7.2.10 Single- and multiple-station smoke alarms.
Listed single- and multiple-station smoke alarms complying with this Code shall be installed in accordance with Clauses 10.7.2.10.1 through 10.7.2.10.7 and ISO 7240.

10.7.2.10.1 Group R-1.
Single- or multiple-station smoke alarms shall be installed in all of the following locations in Group R-1:

1. In sleeping areas.
2. In every room in the path of the means of escape from the sleeping area to the door leading from the sleeping unit.
3. In each storey within the sleeping unit, including basements. For sleeping units with split levels and without an intervening door between the adjacent levels, a smoke alarm installed on the upper level shall suffice for the adjacent lower level provided that the lower level is less than one full storey below the upper level.

10.7.2.10.2 Groups R-2, R-3, R-4 and I-1.
Single-or multiple-station smoke alarms shall be installed and maintained in Groups R-2, R-3, R-4 and I-1 regardless of occupant load at all of the following locations:

1. On the ceiling or wall outside of each separate sleeping area in the immediate vicinity of bedrooms.
2. In each room used for sleeping purposes.
3. In each storey within a dwelling unit, including basements but not including crawl spaces and uninhabitable attics. In dwellings or dwelling units with split levels and without an intervening door between the adjacent levels, a smoke alarm installed on the upper level shall suffice for the adjacent lower level provided that the lower level is less than one full storey below the upper level.

10.7.2.10.3 Installation near cooking appliances.
Smoke alarms shall not be installed in the following locations unless this would prevent placement of a smoke alarm in a location required by Clause 10.7.2.10.1 or 10.7.2.10.2:

1. Ionization smoke alarms shall not be installed less than 6096 mm (20 feet) horizontally from a permanently installed cooking appliance.
2. Ionization smoke alarms with an alarm-silencing switch shall not be installed less than 3048 mm (10 feet) horizontally from a permanently installed cooking appliance.
3. Photoelectric smoke alarms shall not be installed less than 1829 mm (6 feet) horizontally from a permanently installed cooking appliance.

10.7.2.10.4 Installation near bathrooms.
Smoke alarms shall be installed not less than 914 mm (3 feet) horizontally from the door or opening of a bathroom that contains a bathtub or shower unless this would prevent placement of a smoke alarm required by Clause 10.7.2.10.1 or 10.7.2.10.2.
10.7.2.10.5 Interconnection.

Where more than one smoke alarm is required to be installed within an individual dwelling unit or sleeping unit in Group R or I-1 occupancies, the smoke alarms shall be interconnected in such a manner that the activation of one alarm will activate all of the alarms in the individual unit. Physical interconnection of smoke alarms shall not be required where listed wireless alarms are installed and all alarms sound upon activation of one alarm. The alarm shall be clearly audible in all bedrooms over background noise levels with all intervening doors closed.

10.7.2.10.6 Power source.

In new construction, required smoke alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source and shall be equipped with a battery backup. Smoke alarms with integral strobes that are not equipped with battery backup shall be connected to an emergency electrical system in accordance with Clause 28.13. Smoke alarms shall emit a signal when the batteries are low. Wiring shall be permanent and without a disconnecting switch other than as required for overcurrent protection.

Exception: Smoke alarms are not required to be equipped with battery backup where they are connected to an emergency electrical system that complies with Clause 28.13.

10.7.2.10.7 Smoke detection system.

Smoke detectors listed in accordance with this Code and provided as part of the building fire alarm system shall be an acceptable alternative to single- and multiple-station smoke alarms and shall comply with the following:

1. The fire alarm system shall comply with all applicable requirements in Clause 10.7.

2. Activation of a smoke detector in a dwelling unit or sleeping unit shall initiate alarm notification in the dwelling unit or sleeping unit in accordance with Clause 10.7.5.2.

3. Activation of a smoke detector in a dwelling unit or sleeping unit shall not activate alarm notification appliances outside of the dwelling unit or sleeping unit, provided that a supervisory signal is generated and monitored in accordance with Clause 10.7.6.6.

10.7.2.11 Special amusement buildings.

An automatic smoke detection system shall be provided in special amusement buildings in accordance with Clauses 10.7.2.11.1 through 10.7.2.11.3.

10.7.2.11.1 Alarm.

Activation of any single smoke detector, the automatic sprinkler system or any other automatic fire detection device shall immediately activate an audible and visible alarm at the building at a constantly attended location from which emergency action can be initiated, including the capability of manual initiation of requirements in Clause 10.7.2.11.2.

10.7.2.11.2 System response.

The activation of two or more smoke detectors, a single smoke detector equipped with an alarm verification feature, the automatic sprinkler system or other approved fire detection device shall automatically do all of the following:

1. Cause illumination of the means of escape with light of not less than 1 footcandle (11 lux) at the walking surface level.

2. Stop any conflicting or confusing sounds and visual distractions.

3. Activate an approved directional exit marking that will become apparent in an emergency.

4. Activate a prerecorded message, audible throughout the special amusement building, instructing patrons to proceed to the nearest exit. Alarm signals used in conjunction with the prerecorded message shall produce a sound that is distinctive from other sounds used during normal operation.
10.7.2.11.3 Emergency voice/alarm communication system.

An emergency voice/alarm communication system, which is allowed to serve as a public address system, shall be installed in accordance with Clause 10.7.5.2.2 and be audible throughout the entire special amusement building.

10.7.2.12 High-rise buildings.

High-rise buildings shall be provided with an automatic smoke detection system in accordance with Clause 10.7.2.12.1, a fire department communication system in accordance with Clause 10.7.2.12.2 and an emergency voice/alarm communication system in accordance with Clause 10.7.5.2.2.

Exceptions:

1. Airport traffic control towers in accordance with Clauses 4.12 and 10.7.2.21.
2. Open parking garages in accordance with Clause 4.6.5.
4. Low-hazard special occupancies in accordance with Clause 6.3.1.1.
5. Buildings with an occupancy in Group H-1, H-2 or H-3 in accordance with Clause 415.
6. In Group I-1 and I-2 occupancies, the alarm shall sound at a constantly attended location and occupant notification shall be broadcast by the emergency voice/alarm communication system.

10.7.2.12.1 Automatic smoke detection.

Automatic smoke detection in high-rise buildings shall be in accordance with Clauses 10.7.2.12.1.1 and 10.7.2.12.1.2.

10.7.2.12.1.1 Area smoke detection.

Area smoke detectors shall be provided in accordance with this clause. Smoke detectors shall be connected to an automatic fire alarm system. The activation of any detector required by this clause shall activate the emergency voice/alarm communication system in accordance with Clause 10.7.5.2.2. In addition to smoke detectors required by Clauses 10.7.2.1 through 10.7.2.9, smoke detectors shall be located as follows:

1. In each mechanical equipment, electrical, transformer, telephone equipment or similar room that is not provided with sprinkler protection.
2. In each elevator machine room, machinery space, control room and control space and in elevator lobbies.

10.7.2.12.1.2 Duct smoke detection.

Duct smoke detectors complying with Clause 10.7.3.1 shall be located as follows:

1. In the main return air and exhaust air plenum of each air-conditioning system having a capacity greater than 2,000 cubic feet per minute (cfm) (0.94 m³/s). Such detectors shall be located in a serviceable area downstream of the last duct inlet.
2. At each connection to a vertical duct or riser serving two or more stories from a return air duct or plenum of an air-conditioning system. In Group R-1 and R-2 occupancies, a smoke detector is allowed to be used in each return air riser carrying not more than 2.4 m³/s (5,000 cfm) and serving not more than 10 air-inlet openings.

10.7.2.12.2 Fire department communication system.

Where a wired communication system is approved in lieu of an emergency responder radio coverage system in accordance with the Ghana Fire Code, the wired fire department communication system shall be designed and
installed in accordance with ISO 7240 and shall operate between a fire command center complying with Clause 911, elevators, elevator lobbies, emergency and standby power rooms, fire pump rooms, areas of refuge and inside interior exit stairways. The fire department communication device shall be provided at each floor level within the interior exit stairway.

10.7.2.12.3 Multiple-channel voice evacuation.
In buildings with an occupied floor more than 36 576 mm (120 feet) above the lowest level of fire department vehicle access, voice evacuation systems for high-rise buildings shall be multiple-channel systems.

10.7.2.13 Atriums connecting more than two stories.
A fire alarm system shall be installed in occupancies with an atrium that connects more than two stories, with smoke detection installed in locations required by a rational analysis in Clause 10.9.4 and in accordance with the system operation requirements in Clause 10.9.17. The system shall be activated in accordance with Clause 10.7.5. Such occupancies in Group A, E or M shall be provided with an emergency voice/alarm communication system complying with the requirements of Clause 10.7.5.2.2.

10.7.2.14 High-piled combustible storage areas.
An automatic smoke detection system shall be installed throughout high-piled combustible storage areas where required by the Ghana Fire Code.

10.7.2.15 Aerosol storage uses.
Aerosol product rooms and general-purpose warehouses containing aerosol products shall be provided with an approved manual fire alarm system where required by the Ghana Fire Code.

10.7.2.16 Timber, wood structural panel and veneer mills.
Timber, wood structural panel and veneer mills shall be provided with a manual fire alarm system.

10.7.2.17 Underground buildings with smoke control systems.
Where a smoke control system is installed in an underground building in accordance with this Code, automatic smoke detectors shall be provided in accordance with Clause 10.7.2.17.1.

10.7.2.17.1 Smoke detectors.
Not less than one smoke detector listed for the intended purpose shall be installed in all of the following areas:

1. Mechanical equipment, electrical, transformer, telephone equipment, elevator machine or similar rooms.
2. Elevator lobbies.
3. The main return and exhaust air plenum of each air-conditioning system serving more than one storey and located in a serviceable area downstream of the last duct inlet.
4. Each connection to a vertical duct or riser serving two or more floors from return air ducts or plenums of heating, ventilating and air-conditioning systems, except that in Group R occupancies, a listed smoke detector is allowed to be used in each return air riser carrying not more than 2.4 m³/s (5,000 cfm) and serving not more than 10 air-inlet openings.

10.7.2.17.2 Alarm required.
Activation of the smoke control system shall activate an audible alarm at a constantly attended location.

10.7.2.18 Deep underground buildings.
Where the lowest level of a structure is more than 18 288 mm (60 feet) below the finished floor of the lowest level of exit discharge, the structure shall be equipped throughout with a manual fire alarm system, including an emergency voice/alarm communication system installed in accordance with Clause 10.7.5.2.2.

10.7.2.19 Covered and open mall buildings.
Where the total floor area exceeds 4645 m² (50,000 square feet) within either a covered mall building or within the perimeter line of an open mall building, an emergency voice/alarm communication system shall be provided. Access to emergency voice/alarm communication systems serving a mall, required or otherwise, shall be provided for the fire department. The system shall be provided in accordance with Clause 10.7.5.2.2.

10.7.2.20 Residential aircraft hangars.
Not fewer than one single-station smoke alarm
shall be installed within a residential aircraft hangar as defined in Part 2 and shall be interconnected into the residential smoke alarm or other sounding device to provide an alarm that will be audible in all sleeping areas of the dwelling.

10.7.2.21 Airport traffic control towers. An automatic smoke detection system that activates the occupant notification system in accordance with Clause 907.5 shall be provided in airport control towers in accordance with Clauses 10.7.2.21.1 and 10.7.2.21.2.

**Exception:** Audible appliances shall not be installed within the control tower cab.

10.7.2.21.1 Airport traffic control towers with multiple exits and automatic sprinklers. Airport traffic control towers with multiple exits and equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 shall be provided with smoke detectors in all of the following locations:

1. Airport traffic control cab.
2. Electrical and mechanical equipment rooms.
3. Airport terminal radar and electronics rooms.
4. Outside each opening into interior exit stairways.
5. Along the single means of Escape permitted from observation levels.
6. Outside each opening into the single means of Escape permitted from observation levels.

10.7.2.21.2 Other airport traffic control towers. Airport traffic control towers with a single exit or where sprinklers are not installed throughout shall be provided with smoke detectors in all of the following locations:

1. Airport traffic control cab.
2. Electrical and mechanical equipment rooms.
3. Airport terminal radar and electronics rooms.
4. Office spaces incidental to the tower operation.
5. Lounges for employees, including sanitary facilities.
7. Utility shafts where access to smoke detectors can be provided.

10.7.2.22 Battery rooms. An automatic smoke detection system shall be installed in areas containing stationary storage battery systems as required in the Ghana Fire Code.

10.7.2.23 Capacitor energy storage systems. An automatic smoke detection system shall be installed in areas containing capacitor energy storage systems as required by this Code.

10.7.3 Fire safety functions. Automatic fire detectors utilized for the purpose of performing fire safety functions shall be connected to the building’s fire alarm control unit where a fire alarm system is required by Clause 10.7.2. Detectors shall, upon actuation, perform the intended function and activate the alarm notification appliances or activate a visible and audible supervisory signal at a constantly attended location. In buildings not equipped with a fire alarm system, the automatic fire detector shall be powered by normal electrical service and, upon actuation, perform the intended function. The detectors shall be located in accordance with ISO 7240.

10.7.3.1 Duct smoke detectors. Smoke detectors installed in ducts shall be listed for the air velocity, temperature and humidity present in the duct. Duct smoke detectors shall be connected to the building’s fire alarm control unit where a fire alarm system is required by Clause 10.7.2. Activation of a duct smoke detector shall initiate a visible and audible supervisory signal at a constantly attended location and shall perform the intended fire safety function in accordance with this Code. In facilities that are required to be monitored by a supervising station, duct smoke detectors shall report only as a supervisory signal and not as a fire alarm. They shall not be used as a substitute for required open area detection.

**Exceptions:**
1. The supervisory signal at a constantly attended location is not required where duct smoke detectors activate the building’s alarm notification appliances.

2. In occupancies not required to be equipped with a fire alarm system, actuation of a smoke detector shall activate a visible and an audible signal in an approved location. Smoke detector trouble conditions shall activate a visible or audible signal in an approved location and shall be identified as air duct detector trouble.

10.7.3.2 Special locking systems.
Where special locking systems are installed on means of escape doors in accordance with Clauses 11.10.1.9.6 or 11.10.1.9.7, an automatic detection system shall be installed as required by that clause.

10.7.3.3 Elevator emergency operation.
Automatic fire detectors installed for elevator emergency operation shall be installed in accordance with the provisions of ASME A17.1/CSA B44 and ISO 7240.

10.7.3.4 Wiring.
The wiring to the auxiliary devices and equipment used to accomplish the fire safety functions shall be monitored for integrity in accordance with ISO 7240.

10.7.4 Initiating devices.
Where manual or automatic alarm initiation is required as part of a fire alarm system, the initiating devices shall be installed in accordance with Clauses 10.7.4.1 through 10.7.4.3.1.

10.7.4.1 Protection of fire alarm control unit.
In areas that are not continuously occupied, a single smoke detector shall be provided at the location of each fire alarm control unit, notification appliance circuit power extenders, and supervising station transmitting equipment.

Exception: Where ambient conditions prohibit installation of a smoke detector, a heat detector shall be permitted.

10.7.4.2 Manual fire alarm boxes.
Where a manual fire alarm system is required by another clause of this Code, it shall be activated by fire alarm boxes installed in accordance with Clauses 10.7.4.2.1 through 10.7.4.2.6.

10.7.4.2.1 Location.
Manual fire alarm boxes shall be located not more than 1524 mm (5 feet) from the entrance to each exit. In buildings not protected by an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, additional manual fire alarm boxes shall be located so that the distance of travel to the nearest box does not exceed 60 960 mm (200 feet).

10.7.4.2.2 Height.
The height of the manual fire alarm boxes shall be not less than 1067 mm (42 inches) and not more than 1372 mm (48 inches) measured vertically, from the floor level to the activating handle or lever of the box.

10.7.4.2.3 Color.
Manual fire alarm boxes shall be red in color.

10.7.4.2.4 Signs.
Where fire alarm systems are not monitored by a supervising station, an approved permanent sign shall be installed adjacent to each manual fire alarm box that reads: WHEN ALARM SOUNDS CALL FIRE DEPARTMENT.

Exception: Where the manufacturer has permanently provided this information on the manual fire alarm box.

10.7.4.2.5 Protective covers.
The fire Code official is authorized to require the installation of listed manual fire alarm box protective covers to prevent malicious false alarms or to provide the manual fire alarm box with protection from physical damage. The protective cover shall be transparent or red in color with a transparent face to permit visibility of the manual fire alarm box. Each cover shall include proper operating instructions. A protective cover that emits a local alarm signal shall not be installed unless approved. Protective covers shall not project more than that permitted by Clause 11.3.3.3.

10.7.4.2.6 Unobstructed and unobscured.
Manual fire alarm boxes shall be provided with ready access, unobstructed, unobscured and visible at all times.

10.7.4.3 Automatic smoke detection.
Where an automatic smoke detection system is required it shall utilize smoke detectors unless ambient conditions prohibit such an installation. In spaces where smoke detectors cannot be
utilized due to ambient conditions, approved automatic heat detectors shall be permitted.

10.7.4.3.1 Automatic sprinkler system.

For conditions other than specific fire safety functions noted in Clause 10.7.3, in areas where ambient conditions prohibit the installation of smoke detectors, an automatic sprinkler system installed in such areas in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and that is connected to the fire alarm system shall be approved as automatic heat detection.

10.7.5 Occupant notification systems.

A fire alarm system shall annunciate at the fire alarm control unit and shall initiate occupant notification upon activation, in accordance with Clauses 10.7.5.1 through 10.7.5.2.3.3. Where a fire alarm system is required by another clause of this Code, it shall be activated by:

1. Automatic fire detectors.
2. Automatic sprinkler system workflow devices.
4. Automatic fire-extinguishing systems.

**Exception:** Where notification systems are allowed elsewhere in Clause 907 to annunciate at a constantly attended location

10.7.5.1 Presignal feature.

A presignal feature shall not be installed unless approved by the fire Code official. Where a presignal feature is provided, a signal shall be annunciated at a constantly attended location approved by the fire Code official so that occupant notification can be activated in the event of fire or other emergency.

10.7.5.2 Alarm notification appliances.

Alarm notification appliances shall be provided and shall be listed for their purpose.

10.7.5.2.1 Audible alarms.

Audible alarm notification appliances shall be provided and emit a distinctive sound that is not to be used for any purpose other than that of a fire alarm.

**Exceptions:**

1. Audible alarm notification appliances are not required in critical care areas of

Group I-2, Condition 2 occupancies that are in compliance with Clause 10.7.2.6, Exception 2.

2. A visible alarm notification appliance installed in a nurses’ control station or other continuously attended staff location in a Group I-2, Condition 2 suite shall be an acceptable alternative to the installation of audible alarm notification appliances throughout the suite in Group I-2, Condition 2 occupancies that are in compliance with Clause 10.7.2.6, Exception 2.

3. Where provided, audible notification appliances located in each enclosed occupant evacuation elevator lobby in accordance with Clause 31.8.9.1 shall be connected to a separate notification zone for manual paging only.

**10.7.5.2.1.1 Average sound pressure.**

The audible alarm notification appliances shall provide a sound pressure level of 15 decibels (dBA) above the average ambient sound level or 5 dBA above the maximum sound level having a duration of not less than 60 seconds, whichever is greater, in every occupiable space within the building.

**10.7.5.2.1.2 Maximum sound pressure.**

The maximum sound pressure level for audible alarm notification appliances shall be 110 dBA at the minimum hearing distance from the audible appliance. Where the average ambient noise is greater than 95 dBA, visible alarm notification appliances shall be provided in accordance with ISO 7240 and audible alarm notification appliances shall not be required.

**10.7.5.2.2 Emergency voice/alarm communication systems.**

Emergency voice/alarm communication systems required by this Code shall be designed and installed in accordance with ISO 7240. The operation of any automatic fire detector, sprinkler workflow device or manual fire alarm box shall automatically sound an alert tone followed by voice instructions giving approved information and directions for a general or staged evacuation in accordance with the building’s fire safety and evacuation plans required by Clause 404 of the Ghana Fire Code. In high-rise buildings, the system shall operate on at least the alarming floor, the floor above and the floor below. Speakers shall be provided throughout the building by paging
zones. At a minimum, paging zones shall be provided as follows:

1. Elevator groups.
2. Interior exit stairways.
3. Each floor.
4. Areas of refuge as defined in Part 2.

**Exception:** In Group I-1 and I-2 occupancies, the alarm shall sound in a constantly attended area and a general occupant notification shall be broadcast over the overhead page.

**10.7.5.2.2.1 Manual override.**
A manual override for emergency voice communication shall be provided on a selective and all-call basis for all paging zones.

**10.7.5.2.2.2 Live voice messages.**
The emergency voice/alarm communication system shall have the capability to broadcast live voice messages by paging zones on a selective and all-call basis.

**10.7.5.2.2.3 Alternative uses.**
The emergency voice/alarm communication system shall be allowed to be used for other announcements, provided that the manual fire alarm use takes precedence over any other use.

**10.7.5.2.2.4 Emergency voice/alarm communication captions.**
Where stadiums, arenas and grandstands have 15,000 fixed seats or more and provide audible public announcements, the emergency/voice alarm communication system shall provide pre-recorded or real-time captions. Prerecorded or live emergency captions shall be from an approved location constantly attended by personnel trained to respond to an emergency.

**10.7.5.2.2.5 Emergency power.**
Emergency voice/alarm communications systems shall be provided with emergency power in accordance with Clause 28.13. The system shall be capable of powering the required load for a duration of not less than 24 hours, as required in ISO 7240.

**10.7.5.2.3 Visible alarms.**
Visible alarm notification appliances shall be provided in accordance with Clauses 10.7.5.2.3.1 through 10.7.5.2.3.3.

**Exceptions:**
1. Visible alarm notification appliances are not required in alterations, except where an existing fire alarm system is upgraded or replaced, or a new fire alarm system is installed.
2. Visible alarm notification appliances shall not be required in exits as defined in Part 2.
3. Visible alarm notification appliances shall not be required in elevator cars.
4. Visual alarm notification appliances are not required in critical care areas of Group I-2, Condition 2 occupancies that are in compliance with Clause 10.7.2.6, Exception 2.

**10.7.5.2.3.1 Public use areas and common use areas.**
Visible alarm notification appliances shall be provided in public use areas and common use areas.

**Exception:** Where employee work areas have audible alarm coverage, the notification appliance circuits serving the employee work areas shall be initially designed with not less than 20-percent spare capacity to account for the potential of adding visible notification appliances in the future to accommodate hearing-impaired employee(s).

**10.7.5.2.3.2 Groups I-1 and R-1.**
Habitable spaces in dwelling units and sleeping units in Group I-1 and R-1 occupancies in accordance with Table 10.7.5.2.3.2 shall be provided with visible alarm notification. Visible alarms shall be activated by the in-room smoke alarm and the building fire alarm system.

**TABLE 10.7.5.2.3.2 VISIBLE ALARMS**

<table>
<thead>
<tr>
<th>NUMBER OF SLEEP UNITS</th>
<th>SLEEPING ACCOMMODATIONS WITH VISIBLE ALARMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 25</td>
<td>2</td>
</tr>
<tr>
<td>26 to 50</td>
<td>4</td>
</tr>
<tr>
<td>51 to 75</td>
<td>7</td>
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<tr>
<td>76 to 100</td>
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<td>101 to 150</td>
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<td>151 to 200</td>
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<td>201 to 300</td>
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<td>301 to 400</td>
<td>20</td>
</tr>
<tr>
<td>401 to 500</td>
<td>22</td>
</tr>
<tr>
<td>501 to 1,000</td>
<td>5% of total</td>
</tr>
<tr>
<td>1,001 and over</td>
<td>50 plus 3 for each 100 over</td>
</tr>
</tbody>
</table>
10.7.5.2.3.3 Group R-2.
In Group R-2 occupancies required by Clause 10.7 to have a fire alarm system, each storey that contains dwelling units and sleeping units shall be provided with the capability to support visible alarm notification appliances in accordance with Part 11 of ICC A117.1. Such capability shall accommodate wired or wireless equipment. The future capability shall include one of the following:

1. The interconnection of the building fire alarm system with the unit smoke alarms.

2. The replacement of audible appliances with combination audible/visible appliances.

3. The future extension of the existing wiring from the unit smoke alarm locations to required locations for visible appliances.

10.7.6 Installation and monitoring.
A fire alarm system shall be installed and monitored in accordance with Clauses 10.7.6.1 through 10.7.6.6.2 and ISO 7240.

10.7.6.1 Wiring.
Wiring shall comply with the requirements of Ghana Wiring Code and ISO 7240. Wireless protection systems utilizing radio-frequency transmitting devices shall comply with the special requirements for supervision of low-power wireless systems in ISO 7240.

10.7.6.2 Power supply.
The primary and secondary power supply for the fire alarm system shall be provided in accordance with ISO 7240.

Exception: Back-up power for single-station and multiple-station smoke alarms as required in Clause 10.7.2.10.6.

10.7.6.3 Initiating device identification.
The fire alarm system shall identify the specific initiating device address, location, device type, floor level where applicable and status including indication of normal, alarm, trouble and supervisory status, as appropriate.

Exceptions:

1. Fire alarm systems in single-storey buildings less than 2090 m$^2$ (22,500 square feet) in area.

2. Fire alarm systems that only include manual fire alarm boxes, waterflow initiating devices and not more than 10 additional alarm-initiating devices.

3. Special initiating devices that do not support individual device identification.

4. Fire alarm systems or devices that are replacing existing equipment.

10.7.6.3.1 Annunciation.
The initiating device status shall be annunciated at an approved on-site location.

10.7.6.4 Zones.
Each floor shall be zoned separately and a zone shall not exceed 2090 m$^2$ (22,500 square feet). The length of any zone shall not exceed 91 440 mm (300 feet) in any direction.

Exception: Automatic sprinkler system zones shall not exceed the area permitted by NFPA 13.

10.7.6.4.1 Zoning indicator panel.
A zoning indicator panel and the associated controls shall be provided in an approved location. The visual zone indication shall lock in until the system is reset and shall not be canceled by the operation of an audible-alarm silencing switch.

10.7.6.4.2 High-rise buildings.
In high-rise buildings, a separate zone by floor shall be provided for each of the following types of alarm-initiating devices where provided:

1. Smoke detectors.

2. Sprinkler waterflow devices.


4. Other approved types of automatic fire detection devices or suppression systems.
10.7.6.5 Access.
Access shall be provided to each fire alarm device and notification appliance for periodic inspection, maintenance and testing.

10.7.6.6 Monitoring.
Fire alarm systems required by this part or by the Ghana Fire Code shall be monitored by an approved supervising station in accordance with ISO 7240.

Exception: Monitoring by a supervising station is not required for:

1. Single- and multiple-station smoke alarms required by Clause 10.7.2.10.
2. Smoke detectors in Group I-3 occupancies.
3. Automatic sprinkler systems in one- and two-family dwellings.

10.7.6.6.1 Automatic telephone-dialing devices.
Automatic telephone-dialing devices used to transmit an emergency alarm shall not be connected to any fire department telephone number unless approved by the fire chief.

10.7.6.6.2 Termination of monitoring service.
Termination of fire alarm monitoring services shall be in accordance with Clause 10.1.9 of the Ghana Fire Code.

10.7.7 Acceptance tests and completion.
Upon completion of the installation, the fire alarm system and all fire alarm components shall be tested in accordance with ISO 7240.

10.7.7.1 Single- and multiple-station alarm devices.
When the installation of the alarm devices is complete, each device and interconnecting wiring for multiple-station alarm devices shall be tested in accordance with the smoke alarm provisions of ISO 7240.

10.7.7.2 Record of completion.
A record of completion in accordance with ISO 7240 verifying that the system has been installed and tested in accordance with the approved plans and specifications shall be provided.

10.7.7.3 Instructions.
Operating, testing and maintenance instructions and record drawings ("as-builds") and equipment specifications shall be provided at an approved location.

10.7.8 Inspection, testing and maintenance.
The maintenance and testing schedules and procedures for fire alarm and fire detection systems shall be in accordance with the Ghana Fire Code.

10.8 EMERGENCY ALARM SYSTEMS

10.8.1 Group H occupancies.
Emergency alarms for the detection and notification of an emergency condition in Group H occupancies shall be provided in accordance with Clause 4.15.5.

10.8.2 Group H-5 occupancy.
Emergency alarms for notification of an emergency condition in an HPM facility shall be provided as required in Clause 4.11.3.5.

10.9 SMOKE CONTROL SYSTEMS

10.9.1 Scope and purpose.
This clause applies to mechanical or passive smoke control systems where they are required by other provisions of this Code. The purpose of this clause is to establish minimum requirements for the design, installation and acceptance testing of smoke control systems that are intended to provide a tenable environment for the evacuation or relocation of occupants. These provisions are not intended for the preservation of contents, the timely restoration of operations or for assistance in fire suppression or overhaul activities. Smoke control systems regulated by this clause serve a different purpose than the smoke- and heat-removal provisions found in Clause 10.10. Mechanical smoke control systems shall not be considered exhaust systems under this Code.

10.9.2 General design requirements.
Buildings, structures or parts thereof required by this Code to have a smoke control system or systems shall have such systems designed in accordance with the applicable requirements of Clause 10.9 and the generally accepted and well-established principles of engineering relevant to the design. The construction documents shall include sufficient information
and detail to adequately describe the elements of the design necessary for the proper implementation of the smoke control systems. These documents shall be accompanied by sufficient information and analysis to demonstrate compliance with these provisions.

10.9.3 Special inspection and test requirements.

In addition to the ordinary inspection and test requirements that buildings, structures and parts thereof are required to undergo, smoke control systems subject to the provisions of Clause 10.9 shall undergo special inspections and tests sufficient to verify the proper commissioning of the smoke control design in its final installed condition. The design submission accompanying the construction documents shall clearly detail procedures and methods to be used and the items subject to such inspections and tests. Such commissioning shall be in accordance with generally accepted engineering practice and, where possible, based on published standards for the particular testing involved. The special inspections and tests required by this clause shall be conducted under the same terms in Clause 19.4

10.9.4 Analysis.

A rational analysis supporting the types of smoke control systems to be employed, their methods of operation, the systems supporting them and the methods of construction to be utilized shall accompany the submitted construction documents and shall include, but not be limited to, the items indicated in Clauses 10.9.4.1 through 10.9.4.7.

10.9.4.1 Stack effect.

The system shall be designed such that the maximum probable normal or reverse stack effect will not adversely interfere with the system's capabilities. In determining the maximum probable stack effect, altitude, elevation, weather storey and interior temperatures shall be used.

10.9.4.2 Temperature effect of fire.

Buoyancy and expansion caused by the design fire in accordance with Clause 10.9.9 shall be analyzed. The system shall be designed such that these effects do not adversely interfere with the system’s capabilities.

10.9.4.3 Wind effect.

The design shall consider the adverse effects of wind. Such consideration shall be consistent with the wind-loading provisions of Part 16.

10.9.4.4 HVAC systems.

The design shall consider the effects of the heating, ventilating and air-conditioning (HVAC) systems on both smoke and fire transport. The analysis shall include all permutations of systems status. The design shall consider the effects of the fire on the HVAC systems.

10.9.4.5 Climate.

The design shall consider the effects of low temperatures on systems, property and occupants. Air inlets and exhausts shall be located so as to prevent snow or ice blockage.

10.9.4.6 Duration of operation.

All portions of active or engineered smoke control systems shall be capable of continued operation after detection of the fire event for a period of not less than either 20 minutes or 1.5 times the calculated escape time, whichever is greater.

10.9.4.7 Smoke control system interaction.

The design shall consider the interaction effects of the operation of multiple smoke control systems for all design scenarios.

10.9.5 Smoke barrier construction.

Smoke barriers required for passive smoke control and a smoke control system using the pressurization method shall comply with Clause 8.9. The maximum allowable leakage area shall be the aggregate area calculated using the following leakage area ratios:

1. Walls: $A/A_w = 0.00100$
2. Interior exit stairways and ramps and exit passageways: $A/A_w = 0.00035$
3. Enclosed exit access stairways and ramps and all other shafts: $A/A_w = 0.00150$
4. Floors and roofs: $A/A_f = 0.00050$

where:

$A = \text{Total leakage area, } m^2$ (square feet).

$A_f = \text{Unit floor or roof area of barrier, } m^2$ (square feet).
A_w = \text{Unit wall area of barrier, m}^2 \text{ (square meter)}

The leakage area ratios shown do not include openings due to gaps around doors and operable windows. The total leakage area of the smoke barrier shall be determined in accordance with Clause 10.9.5.1 and tested in accordance with Clause 10.9.5.2.

10.9.5.1 Total leakage area.

Total leakage area of the barrier is the product of the smoke barrier gross area multiplied by the allowable leakage area ratio, plus the area of other openings such as gaps around doors and operable windows.

10.9.5.2 Testing of leakage area.

Compliance with the maximum total leakage area shall be determined by achieving the minimum air pressure difference across the barrier with the system in the smoke control mode for mechanical smoke control systems utilizing the pressurization method. Compliance with the maximum total leakage area of passive smoke control systems shall be verified through methods such as door fan testing or other methods, as approved by the fire Code official.

10.9.5.3 Opening protection.

Openings in smoke barriers shall be protected by automatic-closing devices actuated by the required controls for the mechanical smoke control system. Door openings shall be protected by fire door assemblies complying with Clause 8.16.

Exceptions:

1. Passive smoke control systems with automatic-closing devices actuated by spot-type smoke detectors listed for releasing service installed in accordance with Clause 10.7.3.

2. Fixed openings between smoke zones that are protected utilizing the airflow method.

3. In Group I-1, Condition 2; Group I-2; and ambulatory care facilities, where a pair of opposite-swinging doors is installed across a corridor in accordance with Clause 10.9.5.3.1, the doors shall not be required to be protected in accordance with Clause 8.16. The doors shall be close-fitting within operational tolerances and shall not have a center mullion or undercuts in excess of 19.1 mm (0.75 inch), louvers or grilles. The doors shall have fire and jamb stops and astragals or rabbets at meeting edges and, where permitted by the door manufacturer’s listing, positive-latching devices are not required.

4. In Group I-2 and ambulatory care facilities, where such doors are special-purpose horizontal sliding, accordion or folding door assemblies installed in accordance with Clause 11.10.1.4.3 and are automatic closing by smoke detection in accordance with Clause 8.16.2.6.5.

5. Group I-3.

6. Openings between smoke zones with clear ceiling heights of 14 feet (4267 mm) or greater and bank-down capacity of greater than 20 minutes as determined by the design fire size.

10.9.5.3.1 Group I-1, Condition 2; Group I-2; and ambulatory care facilities.

In Group I-1, Condition 2; Group I-2; and ambulatory care facilities, where doors are installed across a corridor, the doors shall be automatic closing by smoke detection in accordance with Clause 8.16.2.6.5 and shall have a vision panel with fire-protection-rated glazing materials in fire protection-rated frames, the area of which shall not exceed that tested.

10.9.5.3.2 Ducts and air transfer openings.

Ducts and air transfer openings are required to be protected with a minimum Class II, 121°C (250°F) smoke damper complying with Clause 8.17.

10.9.6 Pressurization method.

The primary mechanical means of controlling smoke shall be by pressure differences across smoke barriers. Maintenance of a tenable environment is not required in the smoke control zone of fire origin.

10.9.6.1 Minimum pressure difference.

The pressure difference across a smoke barrier used to separate smoke zones shall be not less than 0.05-inch water gage (0.0124 kPa) in fully sprinklered buildings.

In buildings permitted to be other than fully sprinklered, the smoke control system shall be designed to achieve pressure differences not less than two times the maximum calculated pressure difference produced by the design fire.
10.9.6.2 Maximum pressure difference.
The maximum air pressure difference across a smoke barrier shall be determined by required door-opening or closing forces. The actual force required to open exit doors when the system is in the smoke control mode shall be in accordance with Clause 10.10.1.3. Opening and closing forces for other doors shall be determined by standard engineering methods for the resolution of forces and reactions. The calculated force to set a side-hinged, swinging door in motion shall be determined by:

\[ F = F_{dc} + K(WA\Delta P)/(2(W-d)) \]

where:
- \( A \) = Door area, \( m^2 \) (square feet).
- \( D \) = Distance from door handle to latch edge of door, feet (m).
- \( F \) = Total door opening force, pounds (N).
- \( F_{dc} \) = Force required to overcome closing device, pounds (N).
- \( K \) = Coefficient 1.0 (5.2).
- \( W \) = Door width, m (feet).
- \( \Delta P \) = Design pressure difference, inches of water (Pa).

10.9.6.3 Pressurized stairways and elevator hoistways.
Where stairways or elevator hoistways are pressurized, such pressurization systems shall comply with Clause 10.9 as smoke control systems, in addition to the requirements of Clauses 10.9.20 of this Code and 10.9.21 of the Ghana Fire Code.

10.9.7 Airflow design method.
Where approved by the fire Code official, smoke migration through openings fixed in a permanently open position, which are located between smoke control zones by the use of the airflow method, shall be permitted. The design airflow shall be in accordance with this clause. Airflow shall be directed to limit smoke migration from the fire zone. The geometry of openings shall be considered to prevent flow reversal from turbulent effects. Smoke control systems using the airflow method shall be designed in accordance with the Ghana Fire Code.

10.9.7.1 Prohibited conditions.
This method shall not be employed where either the quantity of air or the velocity of the airflow will adversely affect other portions of the smoke control system, unduly intensify the fire, disrupt plume dynamics or interfere with exiting. Airflow toward the fire shall not exceed 200 feet per minute (1.02 m/s). Where the calculated airflow exceeds this limit, the airflow method shall not be used. (Equation 10-1)

10.9.8 Exhaust method.
Where approved by the fire Code official, mechanical smoke control for large enclosed volumes, such as in atriums or malls, shall be permitted to utilize the exhaust method. Smoke control systems using the exhaust method shall be designed in accordance with NFPA 92.

10.9.8.1 Smoke layer.
The height of the lowest horizontal surface of the smoke layer interface shall be maintained not less than 1829 mm (6 feet) above a walking surface that forms a portion of a required Escape system within the smoke zone.

10.9.9 Design fire.
The design fire shall be based on a rational analysis performed by the registered design professional and approved by the fire Code official. The design fire shall be based on the analysis in accordance with Clause 10.9.4 and this clause.

10.9.9.1 Factors considered.
The engineering analysis shall include the characteristics of the fuel, fuel load, effects included by the fire and whether the fire is likely to be steady or unsteady.

10.9.9.2 Design fire fuel.
Determination of the design fire shall include consideration of the type of fuel, fuel spacing and configuration.

10.9.9.3 Heat-release assumptions.
The analysis shall make use of best available data from approved sources and shall not be based on excessively stringent limitations of combustible material.

10.9.9.4 Sprinkler effectiveness assumptions.
A documented engineering analysis shall be provided for conditions that assume fire growth is halted at the time of sprinkler activation.
10.9.10 Equipment.
Equipment including, but not limited to, fans, ducts, automatic dampers and balance dampers, shall be suitable for its intended use, suitable for the probable exposure temperatures that the rational analysis indicates and as approved by the fire Code official.

10.9.10.1 Exhaust fans.
Components of exhaust fans shall be rated and certified by the manufacturer for the probable temperature rise to which the components will be exposed. This temperature rise shall be computed by:

\[ T_s = (Q_c / mc) + (T_a) \]  
(Equation 10-2)

where:
- \( c \) = Specific heat of smoke at smoke layer temperature, kJ/kg \cdot K (Btu/lb\(^\circ\)F).
- \( m \) = Exhaust rate, kg/s (pounds per second).
- \( Q_c \) = Convective heat output of fire, kW (Btu/s).
- \( T_a \) = Ambient temperature, K (\(^\circ\)F).
- \( T_s \) = Smoke temperature, K (\(^\circ\)F).

Exception: Reduced \( T_s \) as calculated based on the assurance of adequate dilution air.

10.9.10.2 Ducts.
Duct materials and joints shall be capable of withstanding the probable temperatures and pressures to which they are exposed as determined in accordance with Clause 10.9.10.1. Ducts shall be constructed and supported in accordance with the International Mechanical Code. Ducts shall be leak tested to 1.5 times the maximum design pressure in accordance with nationally accepted practices. Measured leakage shall not exceed 5 percent of design flow. Results of such testing shall be part of the documentation procedure. Ducts shall be supported directly from fire-resistance-rated structural elements of the building by substantial, noncombustible supports.

Exception: Flexible connections, for the purpose of vibration isolation, complying with this Code and that are constructed of approved fire-resistance-rated materials.

10.9.10.3 Equipment, inlets and outlets.
Equipment shall be located so as to not expose uninvolved portions of the building to an additional fire hazard. Outside air inlets shall be located so as to minimize the potential for introducing smoke or flame into the building. Exhaust outlets shall be so located as to minimize reintroduction of smoke into the building and to limit exposure of the building or adjacent buildings to an additional fire hazard.

10.9.10.4 Automatic dampers.
Automatic dampers, regardless of the purpose for which they are installed within the smoke control system, shall be listed and conform to the requirements of approved, recognized standards.

10.9.10.5 Fans.
In addition to other requirements, belt-driven fans shall have 1.5 times the number of belts required for the design duty, with the minimum number of belts being two. Fans shall be selected for stable performance based on normal temperature and, where applicable, elevated temperature. Calculations and manufacturer’s fan curves shall be part of the documentation procedures. Fans shall be supported and restrained by noncombustible devices in accordance with the requirements of this Code.

Motors driving fans shall not be operated beyond their nameplate horsepower (kilowatts), as determined from measurement of actual current draw, and shall have a minimum service factor of 1.15.

10.9.11 Standby power.
Smoke control systems shall be provided with standby power in accordance with Clause 28.13.

10.9.11.1 Equipment room.
The standby power source and its transfer switches shall be in a room separate from the normal power transformers and switch gears and ventilated directly to and from the exterior. The room shall be enclosed with not less than 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

10.9.11.2 Power sources and power surges.
Elements of the smoke control system relying on volatile memories or the like shall be
supplied with uninterruptable power sources of sufficient duration to span 15-minute primary power interruption. Elements of the smoke control system susceptible to power surges shall be suitably protected by conditioners, suppressors or other approved means.

10.9.12 Detection and control systems. Fire detection systems providing control input or output signals to mechanical smoke control systems or elements thereof shall comply with the requirements of Clause 10.7. Such systems shall be equipped with a control unit complying with this Code and listed as smoke control equipment.

10.9.12.1 Verification.
Control systems for mechanical smoke control systems shall include provisions for verification. Verification shall include positive confirmation of actuation, testing, manual override and the presence of power downstream of all disconnects. A preprogrammed weekly test sequence shall report abnormal conditions audibly, visually and by printed report. The preprogrammed weekly test shall operate all devices, equipment and components used for smoke control.

Exception: Where verification of individual components tested through the preprogrammed weekly testing sequence will interfere with, and produce unwanted effects to, normal building operation, such individual components are permitted to be bypassed from the preprogrammed weekly testing, where approved by the building official and in accordance with both of the following:

1. Where the operation of components is bypassed from the preprogrammed weekly test, presence of power downstream of all disconnects shall be verified weekly by a listed control unit.

2. Testing of all components bypassed from the preprogrammed weekly test shall be in accordance with Clause 10.9.20.6 of the Ghana Fire Code.

10.9.12.2 Wiring.
In addition to meeting requirements of Ghana Wiring Code, all wiring, regardless of voltage, shall be fully enclosed within continuous raceways.

10.9.12.3 Activation.
Smoke control systems shall be activated in accordance with this clause.

10.9.12.3.1 Pressurization, airflow or exhaust method.
Mechanical smoke control systems using the pressurization, airflow or exhaust method shall have completely automatic control.

10.9.12.3.2 Passive method.
Passive smoke control systems actuated by approved spot-type detectors listed for releasing service shall be permitted.

10.9.12.4 Automatic control.
Where completely automatic control is required or used, the automatic-control sequences shall be initiated from an appropriately zoned automatic sprinkler system complying with Clause 10.3.3.1.1, manual controls provided with ready access for the fire department and any smoke detectors required by engineering analysis.

10.9.13 Control air tubing.
Control air tubing shall be of sufficient size to meet the required response times. Tubing shall be flushed clean and dry prior to final connections and shall be adequately supported and protected from damage. Tubing passing through concrete or masonry shall be sleeved and protected from abrasion and electrolytic action.

Control-air tubing shall be hard-drawn copper, Type L, ACR in accordance with ASTM B42, ASTM B43, ASTM B68, ASTM B88, ASTM B251 and ASTM B280. Fittings shall be wrought copper or brass, solder type in accordance with ASME B16.18 or ASME B16.2. Changes in direction shall be made with appropriate tool bends. Brass compression-type fittings shall be used at final connection to devices; other joints shall be brazed using a BCuP-5 brazing alloy with solidus above 1, 593°C (100°F) and liquids below 816°C (1,500°F). Brazing flux shall be used on copper-to-brass joints only.

Exception: Nonmetallic tubing used within control panels and at the final connection to devices provided that all of the following conditions are met:

1. Tubing shall comply with the requirements of this Code.
2. Tubing and connected devices shall be completely enclosed within a galvanized or paint-grade steel enclosure having a minimum thickness of 0.7534 mm (0.0296 inch) (No. 22 gauge). Entry to the enclosure shall be by copper tubing with a protective grommet of neoprene or Teflon or by suitable brass compression to male barbed adapter.

3. Tubing shall be identified by appropriately documented coding.

4. Tubing shall be neatly tied and supported within the enclosure. Tubing bridging cabinets and doors or moveable devices shall be of sufficient length to avoid tension and excessive stress. Tubing shall be protected against abrasion. Tubing connected to devices on doors shall be fastened along hinges.

10.9.13.2 Isolation from other functions. Control tubing serving other than smoke control functions shall be isolated by automatic isolation valves or shall be an independent system.

10.9.13.3 Testing. Control air tubing shall be tested at three times the operating pressure for not less than 30 minutes without any noticeable loss in gauge pressure prior to final connection to devices.

10.9.14 Marking and identification. The detection and control systems shall be clearly marked at all junctions, accesses and terminations.

10.9.15 Control diagrams. Identical control diagrams showing all devices in the system and identifying their location and function shall be maintained current and kept on file with the fire Code official, the fire department and in the fire command center in a format and manner approved by the fire official.

10.9.16 Fire fighter’s smoke control panel. A fire fighter’s smoke control panel for fire department emergency response purposes only shall be provided and shall include manual control or override of automatic control for mechanical smoke control systems. The panel shall be located in a fire command center complying with Clause 10.11 in high-rise buildings or buildings with smoke-protected assembly seating. In all other buildings, the fire fighter’s smoke control panel shall be installed in an approved location adjacent to the fire alarm control panel. The fire fighter’s smoke control panel shall comply with Clauses 10.9.16.1 through 10.9.16.3.

10.9.16.1 Smoke control systems. Fans within the building shall be shown on the fire fighter’s control panel. A clear indication of the direction of airflow and the relationship of components shall be displayed. Status indicators shall be provided for all smoke control equipment, annunciated by fan and zone, and by piplot-lamp-type indicators as follows:

1. Fans, dampers and other operating equipment in their normal status—WHITE.
2. Fans, dampers and other operating equipment in their off or closed status—RED.
3. Fans, dampers and other operating equipment in their on or open status—GREEN.
4. Fans, dampers and other operating equipment in a fault status—YELLOW/AMBER.

10.9.16.2 Smoke control panel. The fire fighter’s control panel shall provide control capability over the complete smoke control system equipment within the building as follows:

1. ON-AUTO-OFF control over each individual piece of operating smoke control equipment that can be controlled from other sources within the building. This includes stairway pressurization fans; smoke exhaust fans; supply, return and exhaust fans; elevator shaft fans and other operating equipment used or intended for smoke control purposes.
2. OPEN-AUTO-CLOSE control over individual dampers relating to smoke control and that are controlled from other sources within the building.
3. ON-OFF or OPEN-CLOSE control over smoke control and other critical equipment associated with a fire or smoke emergency and that can only be controlled from the fire fighter’s control panel.

Exceptions:

1. Complex systems, where approved, where the controls and indicators are combined to control and indicate all elements of a single smoke zone as a unit.

2. Complex systems, where approved, where the control is accomplished by computer interface using approved, plain English commands.

10.9.16.3 Control action and priorities.
The fire-fighter’s control panel actions shall be as follows:

1. ON-OFF and OPEN-CLOSE control actions shall have the highest priority of any control point within the building. Once issued from the fire fighter’s control panel, automatic or manual control from any other control point within the building shall not contradict the control action. Where automatic means are provided to interrupt normal, nonemergency equipment operation or produce a specific result to safeguard the building or equipment including, but not limited to, duct freezestats, duct smoke detectors, high-temperature cutouts, temperature-actuated linkage and similar devices, such means shall be capable of being overridden by the fire fighter’s control panel. The last control action as indicated by each fire fighter’s control panel switch position shall prevail. Control actions shall not require the smoke control system to assume more than one configuration at any one time.

   Exception: Power disconnects required by Ghana Wiring Code.

2. Only the AUTO position of each three-position fire-fighter’s control panel switch shall allow automatic or manual control action from other control points within the building. The AUTO position shall be the NORMAL, nonemergency, building control position. Where a fire fighter’s control panel is in the AUTO position, the actual status of the device (on, off, open, closed) shall continue to be indicated by the status indicator described in Clause 10.9.16.1. Where directed by an automatic signal to assume an emergency condition, the NORMAL position shall become the emergency condition for that device or group of devices within the zone. Control actions shall not require the smoke control system to assume more than one configuration at any one time.

10.9.17 System response time.
Smoke-control system activation shall be initiated immediately after receipt of an appropriate automatic or manual activation command. Smoke control systems shall activate individual components (such as dampers and fans) in the sequence necessary to prevent physical damage to the fans, dampers, ducts and other equipment. For purposes of smoke control, the fire fighter’s control panel response time shall be the same for automatic or manual smoke control action initiated from any other building control point. The total response time, including that necessary for detection, shutdown of operating equipment and smoke control system startup, shall allow for full operational mode to be achieved before the conditions in the space exceed the design smoke condition. The system response time for each component and their sequential relationships shall be detailed in the required rational analysis and verification of their installed condition reported in the required final report.

10.9.18 Acceptance testing.
Devices, equipment, components and sequences shall be individually tested. These tests, in addition to those required by other provisions of this Code, shall consist of determination of function, sequence and, where applicable, capacity of their installed condition.
10.9.18.1 Detection devices.
Smoke or fire detectors that are a part of a smoke control system shall be tested in accordance with Part 9 in their installed condition. Where applicable, this testing shall include verification of airflow in both minimum and maximum conditions.

10.9.18.2 Ducts.
Ducts that are a part of a smoke control system shall be traversed using generally accepted practices to determine actual air quantities.

10.9.18.3 Dampers.
Dampers shall be tested for function in their installed condition.

10.9.18.4 Inlets and outlets.
Inlets and outlets shall be read using generally accepted practices to determine air quantities.

10.9.18.5 Fans.
Fans shall be examined for correct rotation. Measurements of voltage, amperage, revolutions per minute (rpm) and belt tension shall be made.

10.9.18.6 Smoke barriers.
Measurements using inclined manometers or other approved calibrated measuring devices shall be made of the pressure differences across smoke barriers. Such measurements shall be conducted for each possible smoke control condition.

10.9.18.7 Controls.
Each smoke zone equipped with an automatic-initiation device shall be put into operation by the actuation of one such device. Each additional device within the zone shall be verified to cause the same sequence without requiring the operation of fan motors in order to prevent damage. Control sequences shall be verified throughout the system, including verification of override from the fire fighter’s control panel and simulation of standby power conditions.

10.9.18.8 Testing for smoke control.
Smoke control systems shall be tested by a special inspector in accordance with Clause 19.5.16.

10.9.18.8.1 Scope of testing.
Testing shall be conducted in accordance with the following:

- During erection of ductwork and prior to concealment for the purposes of leakage testing and recording of device location.
- Prior to occupancy and after sufficient completion for the purposes of pressure-difference testing, flow measurements, and detection and control verification.

10.9.18.8.2 Qualifications.
Approved agencies for smoke control testing shall have expertise in fire protection engineering, mechanical engineering and certification as air balancers.

10.9.18.8.3 Reports.
A complete report of testing shall be prepared by the approved agency. The report shall include identification of all devices by manufacturer, nameplate data, design values, measured values and identification tag or mark. The report shall be reviewed by the responsible registered design professional and, when satisfied that the design intent has been achieved, the responsible registered design professional shall sign, seal and date the report.

10.9.18.8.3.1 Report filing.
A copy of the final report shall be filed with the fire Code official and an identical copy shall be maintained in an approved location at the building.

10.9.19 System acceptance.
Buildings, or portions thereof, required by this Code to comply with this clause shall not be issued a certificate of occupancy until such time that the fire Code official determines that the
provisions of this clause have been fully complied with and that the fire department has received satisfactory instruction on the operation, both automatic and manual, of the system and a written maintenance program complying with the requirements of Clause 10.9.20.1 of the Ghana Fire Code has been submitted and approved by the fire Code official.

Exception: In buildings of phased construction, a temporary certificate of occupancy, as approved by the fire Code official, shall be allowed provided that those portions of the building to be occupied meet the requirements of this clause and that the remainder does not pose a significant hazard to the safety of the proposed occupants or adjacent buildings.

10.9.20 Smoke proof enclosures.

Where required by Clause 11.23.11, a smokeproof enclosure shall be constructed in accordance with this clause. A smokeproof enclosure shall consist of an interior exit stairway or ramp that is enclosed in accordance with the applicable provisions of Clause 11.23 and an open exterior balcony or ventilated vestibule meeting the requirements of this clause. Where access to the roof is required by the Ghana Fire Code, such access shall be from the smokeproof enclosure where a smokeproof enclosure is required.

10.9.20.1 Access.

Access to the stairway or ramp shall be by way of a vestibule or an open exterior balcony. The minimum dimension of the vestibule shall be not less than the required width of the corridor leading to the vestibule but shall not have a width of less than 1118 mm (44 inches) and shall not have a length of less than 1829 mm (72 inches) in the direction of Escape travel.

10.9.20.2 Construction.

The smokeproof enclosure shall be separated from the remainder of the building by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. The open exterior balcony shall be constructed in accordance with the fire-resistance rating requirements for floor assemblies.

10.9.20.2.1 Door closers.

Doors in a smokeproof enclosure shall be self- or automatic closing by actuation of a smoke detector in accordance with Clause 8.16.2.6.6 and shall be installed at the floor-side entrance to the smokeproof enclosure. The actuation of the smoke detector on any door shall activate the closing devices on all doors in the smokeproof enclosure at all levels. Smoke detectors shall be installed in accordance with Clause 10.7.3.

10.9.20.3 Natural ventilation alternative.

The provisions of Clauses 10.9.20.3.1 through 10.9.20.3.3 shall apply to ventilation of smokeproof enclosures by natural means.

10.9.20.3.1 Balcony doors.

Where access to the stairway or ramp is by way of an open exterior balcony, the door assembly into the enclosure shall be a fire door assembly in accordance with Clause 8.16.

10.9.20.3.2 Vestibule doors.

Where access to the stairway or ramp is by way of a vestibule, the door assembly into the vestibule shall be a fire door assembly complying with Clause 8.16. The door assembly from the vestibule to the stairway shall have not less than a 20-minute fire protection rating complying with Clause 8.16.

10.9.20.3.3 Vestibule ventilation.

Each vestibule shall have a minimum net area of 16 square feet (1.5 m²) of opening in a wall facing an outer court, yard or public way that is not less than 20 feet (6096 mm) in width.

10.9.20.4 Mechanical ventilation alternative.

The provisions of Clauses 10.9.20.4.1 through 10.9.20.4.4 shall apply to ventilation of smokeproof enclosures by mechanical means.

10.9.20.4.1 Vestibule doors.

The door assembly from the building into the vestibule shall be a fire door assembly complying with Clause 8.16.2.2.1. The door assembly from the vestibule to the stairway or ramp shall not have less than a 20-minute fire protection rating and shall meet the requirements for a smoke door assembly in
accordance with Clause 8.16.2.2.1. The door shall be installed in accordance with the Ghana Fire Code.

10.9.20.4.2 Vestibule ventilation.
The vestibule shall be supplied with not less than one air change per minute and the exhaust shall be not less than 150 percent of supply. Supply air shall enter and exhaust air shall discharge from the vestibule through separate, tightly constructed ducts used only for that purpose. Supply air shall enter the vestibule within 152 mm (6 inches) of the floor level. The top of the exhaust register shall be located at the top of the smoke trap but not more than 152 mm (6 inches) down from the top of the trap, and shall be entirely within the smoke trap area. Doors in the open position shall not obstruct duct openings. Duct openings with controlling dampers are permitted where necessary to meet the design requirements, but dampers are not otherwise required.

10.9.20.4.2.1 Engineered ventilation system.
Where a specially engineered system is used, the system shall exhaust a quantity of air equal to not less than 90 air changes per hour from any vestibule in the emergency operation mode and shall be sized to handle three vestibules simultaneously. Smoke detectors shall be located at the floor-side entrance to each vestibule and shall activate the system for the affected vestibule. Smoke detectors shall be installed in accordance with Clause 10.7.3.

10.9.20.4.3 Smoke trap.
The vestibule ceiling shall be not less than 20 inches (508 mm) higher than the door opening into the vestibule to serve as a smoke and heat trap and to provide an upward-moving air column. The height shall not be decreased unless approved and justified by design and test.

10.9.20.4.4 Stairway or ramp shaft air movement system.
The stairway or ramp shaft shall be provided with a dampered relief opening and supplied with sufficient air to maintain a minimum positive pressure of 25 Pa (0.10 inch of water) in the shaft relative to the vestibule with all doors closed.

10.9.20.5 Stairway and ramp pressurization alternative.
Where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the vestibule is not required, provided that each interior exit stairway or ramp is pressurized to not less than 25 Pa (0.10 inch of water) and not more than 87 Pa (0.35 inches of water) in the shaft relative to the building measured with all interior exit stairway and ramp doors closed under maximum anticipated conditions of stack effect and wind effect.

10.9.20.6 Ventilating equipment.
The activation of ventilating equipment required by the alternatives in Clauses 10.9.20.4 and 10.9.20.5 shall be by smoke detectors installed at each floor level at an approved location at the entrance to the smokeproof enclosure. When the closing device for the stairway and ramp shaft and vestibule doors is activated by smoke detection or power failure, the mechanical equipment shall activate and operate at the required performance levels. Smoke detectors shall be installed in accordance with Clause 10.7.3.

10.9.20.6.1 Ventilation systems.
Smokeproof enclosure ventilation systems shall be independent of other building ventilation systems. The equipment, control wiring, power wiring and ductwork shall comply with one of the following:

1. Equipment, control wiring, power wiring and ductwork shall be located exterior to the building and directly connected to the smokeproof enclosure or connected to the smokeproof enclosure by ductwork enclosed by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

2. Equipment, control wiring, power wiring and ductwork shall be located within the smokeproof enclosure with intake or exhaust directly from and to the outside or through ductwork enclosed by not less than 2-hour fire barriers constructed in accordance with
Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

3. Equipment, control wiring, power wiring and ductwork shall be located within the building if separated from the remainder of the building, including other mechanical equipment, by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

Exceptions:

1. Control wiring and power wiring located outside of a 2-hour fire barrier construction shall be protected using any one of the following methods:

   1.1. Cables used for survivability of required critical circuits shall be listed in accordance with this Code and shall have a fire-resistance rating of not less than 2 hours.

   1.2. Where encased with not less than 51 mm (2 inches) of concrete.

   1.3. Electrical circuit protective systems shall have a fire-resistance rating of not less than 2 hours. Electrical circuit protective systems shall be installed in accordance with their listing requirements.

10.9.20.6.2 Standby power.
Mechanical vestibule and stairway and ramp shaft ventilation systems and automatic fire detection systems shall be provided with standby power in accordance with Clause 28.13.

10.9.20.6.3 Acceptance and testing.
Before the mechanical equipment is approved, the system shall be tested in the presence of the building official to confirm that the system is operating in compliance with these requirements.

10.9.21 Elevator hoistway pressurization alternative.
Where elevator hoistway pressurization is provided in lieu of required enclosed elevator lobbies, the pressurization system shall comply with Clauses 10.9.21.1 through 10.9.21.11.

10.9.21.1 Pressurization requirements.
Elevator hoistways shall be pressurized to maintain a minimum positive pressure of 25 Pa (0.10 inch of water) and a maximum positive pressure of 67 Pa (0.25 inch of water) with respect to adjacent occupied space on all floors. This pressure shall be measured at the midpoint of each hoistway door, with all elevator cars at the floor of recall and all hoistway doors on the floor of recall open and all other hoistway doors closed. The pressure differentials shall be measured between the hoistway and the adjacent elevator landing. The opening and closing of hoistway doors at each level must be demonstrated during this test. The supply air intake shall be from an outside, uncontaminated source located a minimum distance of 6096 mm (20 feet) from any air exhaust system or outlet.

Exceptions:

1. On floors containing only Group R occupancies, the pressure differential is permitted to be measured between the hoistway and a dwelling unit or sleeping unit.

2. Where an elevator opens into a lobby enclosed in accordance with this Code, the pressure differential is permitted to be measured between the hoistway and the space immediately outside the door(s) from the floor to the enclosed lobby.

3. The pressure differential is permitted to be measured relative to the outdoor atmosphere on floors other than the following:
3.1. The fire floor.

3.2. The two floors immediately below the fire floor.

3.3. The floor immediately above the fire floor.

4. The minimum positive pressure of 25 Pa (0.10 inch of water) and a maximum positive pressure of 67 Pa (0.25 inch of water) with respect to occupied floors are not required at the floor of recall with the doors open.

10.9.21.1 Use of ventilation systems.
Ventilation systems, other than hoistway supply air systems, are permitted to be used to exhaust air from adjacent spaces on the fire floor, two floors immediately below and one floor immediately above the fire floor to the building’s exterior where necessary to maintain positive pressure relationships as required in Clause 10.9.21.1 during operation of the elevator shaft pressurization system.

10.9.21.2 Rational analysis.
A rational analysis complying with Clause 10.9.4 shall be submitted with the construction documents.

10.9.21.3 Ducts for system.
Any duct system that is part of the pressurization system shall be protected with the same fire-resistance rating as required for the elevator shaft enclosure.

909.21.4 Fan system.
The fan system provided for the pressurization system shall be as required by Clauses 10.9.21.4.1 through 10.9.21.4.4.

10.9.21.4.1 Fire resistance.
Where located within the building, the fan system that provides the pressurization shall be protected with the same fire-resistance rating required for the elevator shaft enclosure.

10.9.21.4.2 Smoke detection.
The fan system shall be equipped with a smoke detector that will automatically shut down the fan system when smoke is detected within the system.

10.9.21.4.3 Separate systems.
A separate fan system shall be used for each elevator hoistway.

10.9.21.4.4 Fan capacity.
The supply fan shall be either adjustable with a capacity of not less than 0.4719 m$^3$/s (1,000 cfm) per door, or that specified by a registered design professional to meet the requirements of a designed pressurization system.

10.9.21.5 Standby power.
The pressurization system shall be provided with standby power in accordance with Clause 28.13.

10.9.21.6 Activation of pressurization system.
The elevator pressurization system shall be activated upon activation of either the building fire alarm system or the elevator lobby smoke detectors. Where both a building fire alarm system and elevator lobby smoke detectors are present, each shall be independently capable of activating the pressurization system.

10.9.21.7 Testing.
Testing for performance shall be required in accordance with Clause 10.9.18.8. System acceptance shall be in accordance with Clause 10.9.19.

10.9.21.8 Marking and identification.
Detection and control systems shall be marked in accordance with Clause 10.9.14.

10.9.21.9 Control diagrams.
Control diagrams shall be provided in accordance with Clause 10.9.15.

10.9.21.10 Control panel.
A control panel complying with Clause 10.9.16 shall be provided.

10.9.21.11 System response time.
Hoistway pressurization systems shall comply with the requirements for smoke control system response time in Clause 10.9.17.

10.10 SMOKE AND HEAT REMOVAL

10.10.1 General.
Where required by this Code, smoke and heat vents or mechanical smoke removal systems shall conform to the requirements of this clause.

10.10.2 Where required.
Smoke and heat vents or a mechanical smoke
removal system shall be installed as required by Clauses 10.10.2.1 and 10.10.2.2.

Exceptions:

1. Frozen food warehouses used solely for storage of Class I and II commodities where protected by an approved automatic sprinkler system.
2. Smoke and heat removal shall not be required in areas of buildings equipped with early suppression fast-response (ESFR) sprinklers.
3. Smoke and heat removal shall not be required in areas of buildings equipped with control mode special application sprinklers with a response time index of $50 \ (m \cdot s)^{1/2}$ or less that are listed to control a fire in stored commodities with 12 or fewer sprinklers.

10.10.2.1 Group F-1 or S-1.
Smoke and heat vents installed in accordance with Clause 10.10.3 or a mechanical smoke removal system installed in accordance with Clause 10.10.4 shall be installed in buildings and portions thereof used as a Group F-1 or S-1 occupancy having more than $4645 \ m^2$ (50,000 square feet) of undivided area. In occupied portions of a building equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 where the upper surface of the storey is not a roof assembly, a mechanical smoke removal system in accordance with Clause 10.10.4 shall be installed.

Exception: Group S-1 aircraft repair hangars.

10.10.2.2 High-piled combustible storage.
Smoke and heat removal required by the Ghana Fire Code for buildings and portions thereof containing high-piled combustible storage shall be installed in accordance with Clause 10.10.3 in unsprinklered buildings. In buildings and portions thereof containing high-piled combustible storage equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, a smoke and heat removal system shall be installed in accordance with Clause 10.10.3 or 10.10.4. In occupied portions of a building equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, where the upper surface of the storey is not a roof assembly, a mechanical smoke removal system in accordance with Clause 10.10.4 shall be installed.

10.10.3 Smoke and heat vents.
The design and installation of smoke and heat vents shall be in accordance with Clauses 10.10.3.1 through 10.10.3.3.

10.10.3.1 Listing and labeling.
Smoke and heat vents shall be listed and labeled to indicate compliance with this Code.

10.10.3.2 Smoke and heat vent locations.
Smoke and heat vents shall be located 6096 mm (20 feet) or more from adjacent plot lines and fire walls and 3048 mm (10 feet) or more from fire barriers. Vents shall be uniformly located within the roof in the areas of the building where the vents are required to be installed by Clause 10.10.2 with consideration given to roof pitch, sprinkler location and structural members.

10.10.3.3 Smoke and heat vents area.
The required aggregate area of smoke and heat vents shall be calculated as follows:

For buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1:

$$A_{VR} = \frac{V}{9000} \ (Equation \ 10-3)$$

where:

$$A_{VR} = \text{The required aggregate vent area} \ (ft^2).$$

$$V = \text{Volume} \ (ft^3) \ of \ the \ area \ that \ requires \ smoke \ removal.$$ 

For unsprinklered buildings:

$$A_{VR} = \frac{A_{FA}}{50} \ (Equation \ 10-4)$$

where:

$$A_{VR} = \text{The required aggregate vent area} \ (ft^2).$$

$$A_{FA} = \text{The area of the floor in the area that requires smoke removal}.$$ 

10.10.4 Mechanical smoke removal systems.
Mechanical smoke removal systems shall be
designed and installed in accordance with Clauses 10.10.4.1 through 10.10.4.7.

10.10.4.1 Automatic sprinklers required. The building shall be equipped throughout with an approved automatic sprinkler system in accordance with Clause 10.3.3.1.1.

10.10.4.2 Exhaust fan construction. Exhaust fans that are part of a mechanical smoke removal system shall be rated for operation at 105°C (221°F). Exhaust fan motors shall be located outside of the exhaust fan air stream.

10.10.4.3 System design criteria. The mechanical smoke removal system shall be sized to exhaust the building at a minimum rate of two air changes per hour based on the volume of the building or portion thereof without contents. The capacity of each exhaust fan shall not exceed 14.2 m³/s (30,000 cubic feet per minute).

10.10.4.3.1 Makeup air. Makeup air openings shall be provided within 1829 mm (6 feet) of the floor level. Operation of makeup air openings shall be manual or automatic. The minimum gross area of makeup air inlets shall be 0.74 m² per 0.4719 m³/s (8 square feet per 1,000 cubic feet per minute) of smoke exhaust.

10.10.4.4 Activation. The mechanical smoke removal system shall be activated by manual controls only.

10.10.4.5 Manual control location. Manual controls shall be located where they are able to be accessed by the fire service from an exterior door of the building and separated from the remainder of the building by not less than a 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

10.10.4.6 Control wiring. Wiring for operation and control of mechanical smoke removal systems shall be connected ahead of the main disconnect in accordance with the Ghana Wiring Code and be protected against interior fire exposure to temperatures in excess of 1,000°F (538°C) for a period of not less than 15 minutes.

10.10.4.7 Controls. Where building air-handling and mechanical smoke removal systems are combined or where independent building air-handling systems are provided, fans shall automatically shut down in accordance with this Code. The manual controls provided for the smoke removal system shall have the capability to override the automatic shutdown of fans that are part of the smoke removal system.

10.10.5 Maintenance. Smoke and heat vents and mechanical smoke removal systems shall be maintained in accordance with the Ghana Fire Code.

10.11 FIRE COMMAND CENTER

10.11.1 General. Where required by other clauses of this Code and in buildings classified as high-rise buildings by this Code, a fire command center for fire department operations shall be provided and shall comply with Clauses 10.11.1.1 through 10.11.1.6.

10.11.1.1 Location and access. The location and accessibility of the fire command center shall be approved by the fire Code official.

10.11.1.2 Separation. The fire command center shall be separated from the remainder of the building by not less than the 1-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assembly constructed in accordance with Clause 8.11, or both.

10.11.1.3 Size. The room shall be not less than 19 m² (200 square feet) with a minimum dimension of 3048 mm (10 feet).

10.11.1.4 Layout approval. A layout of the fire command center and all features required by this clause to be contained therein shall be submitted for approval prior to installation.

10.11.1.5 Storage. Storage unrelated to operation of the fire command center shall be prohibited.

10.11.1.6 Required features. The fire command center shall comply with ISO 7240 and shall contain all of the following features:

1. The emergency voice/alarm communication system control unit.
2. The fire department communications system.

3. Fire detection and alarm system annunciator.

4. Annunciator unit visually indicating the location of the elevators and whether they are operational.

5. Status indicators and controls for air distribution systems.

6. The fire fighter’s control panel required by Clause 10.9.16 for smoke control systems installed in the building.

7. Controls for unlocking interior exit stairway doors simultaneously.

8. Sprinkler valve and waterflow detector display panels.

9. Emergency and standby power status indicators.

10. A telephone for fire department use with controlled access to the public telephone system.

11. Fire pump status indicators.

12. Schematic building plans indicating the typical floor plan and detailing the building core, means of Escape, fire protection systems, fire fighter air replenishment system, fire-fighting equipment and fire department access and the location of fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions.

13. An approved Building Information Card that contains, but is not limited to, the following information:
   13.1. General building information that includes: property name, address, the number of floors in the building above and below grade, use and occupancy classification (for mixed uses, identify the different types of occupancies on each floor), and the estimated building population during the day, night and weekend.
   13.2. Building emergency contact information that includes: a list of the building’s emergency contacts including but not limited to building manager and building engineer and their respective work phone number, cell phone number, e-mail address.
   13.3. Building construction information that includes: the type of building construction including but not limited to floors, walls, columns, and roof assembly.
   13.4. Exit access and exit stairway information that includes: number of exit access and exit stairways in the building, each exit access and exit stairway designation and floors served, location where each exit access and exit stairway discharges, interior exit stairways that are pressurized, exit stairways provided with emergency lighting, each exit stairway that allows reentry, exit stairways providing roof access; elevator information that includes: number of elevator banks, elevator bank designation, elevator car numbers and respective floors that they serve; location of elevator machine rooms, control rooms and control spaces; location of sky lobby, location of freight elevator banks.

13.5. Building services and system information that includes: location of mechanical rooms, location of building management system, location and capacity of all fuel oil tanks, location
of emergency generator, location of natural gas service.

13.6. Fire protection system information that includes: location of standpipes, location of fire pump room, location of fire department connections, floors protected by automatic sprinklers, location of different types of automatic sprinkler systems installed including, but not limited to, dry, wet and pre-action.

13.7 Hazardous material information that includes: location of hazardous material, quantity of hazardous material.


15. Generator supervision devices, manual start and transfer features.

16. Public address system, where specifically required by other clauses of this Code.

17. Elevator fire recall switch in accordance with ASME A17.1/BSA 44.

18. Elevator emergency or standby power selector switch(es), where emergency or standby power is provided.

### 10.12 Fire Department Connections

**10.12.1 Installation.**

Fire department connections shall be installed in accordance with the Ghana Fire Code applicable to the system design and shall comply with Clauses 10.12.2 through 10.12.6.

**10.12.2 Location.**

With respect to hydrants, driveways, buildings and landscaping, fire department connections shall be so located that fire apparatus and hose connected to supply the system will not obstruct access to the buildings for other fire apparatus. The location of fire department connections shall be approved by the fire Code official.

**10.12.2.1 Visible location.**

Fire department connections shall be located on the street side of buildings or facing approved fire apparatus access roads, fully visible and recognizable from the street, fire apparatus access road or nearest point of fire department vehicle access or as otherwise approved by the fire Code official.

**10.12.2.2 Existing buildings.**

On existing buildings, wherever the fire department connection is not visible to approaching fire apparatus, the fire department connection shall be indicated by an approved sign mounted on the street front or on the side of the building. Such sign shall have the letters “FDC” not less than 6 inches (152 mm) high and words in letters not less than 2 inches (51 mm) high or an arrow to indicate the location. Such signs shall be subject to the approval of the fire Code official.

**10.12.3 Fire hose threads.**

Fire hose threads used in connection with Fire hydrant systems shall be approved and shall be compatible with fire department hose threads.

**10.12.4 Access.**

Immediate access to fire department connections shall be maintained at all times and without obstruction by fences, bushes, trees, walls or any other fixed or moveable object. Access to fire department connections shall be approved by the fire Code official.

**Exception:** Fences, where provided with an access gate equipped with a sign complying with the legend requirements of this clause and a means of emergency operation. The gate and the means of emergency operation shall be approved by the fire Code official and maintained operational at all times.

**10.12.4.1 Locking fire department connection caps.**

The fire Code official is authorized to require locking caps on fire department connections for water-based fire protection systems where the responding fire department carries appropriate key wrenches for removal.

**10.2.4.2 Clear space around connections.**

A working space of not less than 762 mm (36 inches) in width, 914 mm (36 inches) in depth
and 1981 mm (78 inches) in height shall be provided and maintained in front of and to the sides of wall-mounted fire department connections and around the circumference of free-standing fire department connections, except as otherwise required or approved by the fire Code official.

10.12.4.3 Physical protection.
Where fire department connections are subject to impact by a motor vehicle, vehicle impact protection shall be provided in accordance with the Ghana Fire Code.

10.12.5 Signs.
A metal sign with raised letters not less than 25 mm (1 inch) in size shall be mounted on all fire department connections serving automatic sprinklers, standpipes or fire pump connections. Such signs shall read: AUTOMATIC SPRINKLERS or STANDPIPES or TEST CONNECTION or a combination thereof as applicable. Where the fire department connection does not serve the entire building, a sign shall be provided indicating the portions of the building served.

10.12.6 Backflow protection.
The potable water supply to automatic sprinkler and Fire hydrant systems shall be protected against backflow as required by this Code.

10.13 FIRE PUMPS

10.13.1 General.
Where provided, fire pumps shall be installed in accordance with this clause.

10.13.2 Protection against interruption of service.
The fire pump, driver and controller shall be protected in accordance with the Ghana Fire Code against possible interruption of service through damage caused by explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism and other adverse conditions.

10.13.2.1 Protection of fire pump rooms.
Fire pumps shall be located in rooms that are separated from all other areas of the building by 2-hour fire barriers constructed in accordance with Clause 8.7 or 2-hour horizontal assemblies constructed in accordance with Clause 8.11, or both.

Exceptions:

1. In other than high-rise buildings, separation by 1-hour fire barriers constructed in accordance with Clause 8.7 or 1-hour horizontal assemblies constructed in accordance with Clause 8.11, or both, shall be permitted in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

2. Separation is not required for fire pumps physically separated in accordance with the Ghana Fire Code.

10.13.2.2 Circuits supplying fire pumps.
Cables used for survivability of circuits supplying fire pumps shall be protected using one of the following methods:

1. Cables used for survivability of required critical circuits shall be listed in accordance with this Code and shall have a fire-resistance rating of not less than 1 hour.

2. Electrical circuit protective systems shall have a fire-resistance rating of not less than 1 hour. Electrical circuit protective systems shall be installed in accordance with their listing requirements.

3. Construction having a fire-resistance rating of not less than 1 hour.

10.13.3 Temperature of pump room.
Suitable means shall be provided for maintaining the temperature of a pump room or pump house, where required, above 5°C (40°F).

10.13.3.1 Engine manufacturer’s recommendation.
Temperature of the pump room, pump house or area where engines are installed shall never be less than the minimum recommended by the engine manufacturer. The engine manufacturer’s recommendations for oil heaters shall be followed.

10.13.4 Valve supervision.
Where provided, the fire pump suction, discharge and bypass valves, and isolation valves on the backflow prevention device or assembly shall be supervised open by one of the following methods:
1. Central-station, proprietary or remote-station signaling service.

2. Local signaling service that will cause the sounding of an audible signal at a constantly attended location.

3. Locking valves open.

4. Sealing of valves and approved weekly recorded inspection where valves are located within fenced enclosures under the control of the owner.

10.13.4.1 Test outlet valve supervision. Fire pump test outlet valves shall be supervised in the closed position.

10.13.5 Acceptance test. Acceptance testing shall be done in accordance with the requirements of the Ghana Fire Code.

10.14 EMERGENCY RESPONDER SAFETY FEATURES


10.14.1.1 Exterior access to shaftways. Outside openings accessible to the fire department and that open directly on a hoistway or shaftway communicating between two or more floors in a building shall be plainly marked with the word “SHAFTWAY” in red letters not less than 152 mm (6 inches) high on a white background. Such warning signs shall be placed so as to be readily discernible from the outside of the building.

10.14.1.2 Interior access to shaftways. Door or window openings to a hoistway or shaftway from the interior of the building shall be plainly marked with the word “SHAFTWAY” in red letters not less than 6 inches (152 mm) high on a white background. Such warning signs shall be placed so as to be readily discernible.

Exception: Markings shall not be required on shaftway openings that are readily discernible as openings onto a shaftway by the construction or arrangement.

10.14.2 Equipment room identification. Fire protection equipment shall be identified in an approved manner. Rooms containing controls for air-conditioning systems, sprinkler risers and valves or other fire detection, suppression or control elements shall be identified for the use of the fire department. Approved signs required to identify fire protection equipment and equipment location shall be constructed of durable materials, permanently installed and readily visible.

10.15 CARBON MONOXIDE DETECTION

10.15.1 General. Carbon monoxide detection shall be installed in new buildings in accordance with Clauses 915.1.1 through 915.6. Carbon monoxide detection shall be installed in existing buildings in accordance with Part 11 of the Ghana Fire Code.

10.15.1.1 Where required. Carbon monoxide detection shall be provided in Group I-1, I-2, I-4 and R occupancies and in classrooms in Group E occupancies in the locations specified in Clause 10.15.2 where any of the conditions in Clauses 10.15.1.2 through 10.15.1.6 exist.

10.15.1.2 Fuel-burning appliances and fuel-burning fireplaces. Carbon monoxide detection shall be provided in dwelling units, sleeping units and classrooms that contain a fuel-burning appliance or a fuel-burning fireplace.

10.15.1.3 Fuel burning, forced-air furnaces. Carbon monoxide detection shall be provided in dwelling units, sleeping units and classrooms served by a fuel-burning, forced-air furnace.

Exception: Carbon monoxide detection shall not be required in dwelling units, sleeping units and classrooms if a carbon monoxide detector is provided in the first room or area served by each main duct leaving the furnace, and the carbon monoxide alarm signals are automatically transmitted to an approved location.

10.15.1.4 Fuel-burning appliances outside of dwelling units, sleeping units and
classrooms. Carbon monoxide detection shall be provided in dwelling units, sleeping units and classrooms located in buildings that contain fuel-burning appliances or fuel-burning fireplaces.

Exceptions:

1. Carbon monoxide detection shall not be required in dwelling units, sleeping units and classrooms without communicating openings between the fuel-burning appliance or fuel-burning fireplace and the dwelling unit, sleeping unit or classroom.

2. Carbon monoxide detection shall not be required in dwelling units, sleeping units and classrooms where a carbon monoxide detector is provided in one of the following locations:

   2.1. In an approved location between the fuel-burning appliance or fuel-burning fireplace and the dwelling unit, sleeping unit or classroom.

   2.2. On the ceiling of the room containing the fuel-burning appliance or fuel-burning fireplace.

10.15.1.5 Private garages. Carbon monoxide detection shall be provided in dwelling units, sleeping units and classrooms in buildings with attached private garages.

Exceptions:

1. Carbon monoxide detection shall not be required in dwelling units, sleeping units and classrooms without communicating openings between the private garage and the dwelling unit, sleeping unit or classroom.

2. Carbon monoxide detection shall not be required in dwelling units, sleeping units and classrooms located more than one story above or below a private garage.

3. Carbon monoxide detection shall not be required where the private garage connects to the building through an open-ended corridor.

4. Where a carbon monoxide detector is provided in an approved location between openings to a private garage and dwelling units, sleeping units or classrooms.

10.15.1.6 Exempt garages. For determining compliance with Clause 10.15.1.5, an open parking garage complying with Clause 4.6.5 or an enclosed parking garage complying with Clause 4.6.6 shall not be considered a private garage.

10.15.2 Locations. Where required by Clause 10.15.1.1, carbon monoxide detection shall be installed in the locations specified in Clauses 10.15.2.1 through 10.15.2.3.

10.15.2.1 Dwelling units. Carbon monoxide detection shall be installed in dwelling units outside of each separate sleeping area in the immediate vicinity of the bedrooms. Where a fuel-burning appliance is located within a bedroom or its attached bathroom, carbon monoxide detection shall be installed within the bedroom.

10.15.2.2 Sleeping units. Carbon monoxide detection shall be installed in sleeping units.

Exception: Carbon monoxide detection shall be allowed to be installed outside of each separate sleeping area in the immediate vicinity of the sleeping unit where the sleeping unit or its attached bathroom does not contain a fuel-burning appliance and is not served by a forced air furnace.

10.15.2.3 Group E occupancies. Carbon monoxide detectors shall be installed in classrooms in Group E occupancies. Carbon monoxide alarm signals shall be automatically transmitted to an on-site location that is staffed by school personnel.

Exception: Carbon monoxide alarm signals shall not be required to be automatically transmitted to an on-site location that is staffed by school personnel in Group E occupancies with an occupant load of 30 or less.
10.15.3 Carbon monoxide detection.
Carbon monoxide detection required by Clauses 10.15.1 through 10.15.2.3 shall be provided by carbon monoxide alarms complying with Clause 10.15.4 or carbon monoxide detection systems complying with Clause 10.15.5.

10.15.4 Carbon monoxide alarms.
Carbon monoxide alarms shall comply with Clauses 10.15.4.1 through 10.15.4.4.

10.15.4.1 Power source.
Carbon monoxide alarms shall receive their primary power from the building wiring where such wiring is served from a commercial source, and when primary power is interrupted, shall receive power from a battery. Wiring shall be permanent and without a disconnecting switch other than that required for overcurrent protection.

Exception: Where installed in buildings without commercial power, battery-powered carbon monoxide alarms shall be an acceptable alternative.

10.15.4.2 Listings.
Carbon monoxide alarms shall be listed in accordance with this Code.

10.15.4.3 Locations.
Carbon monoxide alarms shall only be installed in dwelling units and in sleeping units. They shall not be installed in locations where the Code requires carbon monoxide detectors to be used.

10.15.4.4 Combination alarms.
Combination carbon monoxide/smoke alarms shall be an acceptable alternative to carbon monoxide alarms. Combination carbon monoxide/smoke alarms shall be listed in accordance with this Code.

10.15.5 Carbon monoxide detection systems.
Carbon monoxide detection systems shall be an acceptable alternative to carbon monoxide alarms and shall comply with Clauses 10.15.5.1 through 10.15.5.3.

10.15.5.1 General.
Carbon monoxide detection systems shall comply with ISO 72400. Carbon monoxide detectors shall be listed in accordance with this Code.

10.15.5.2 Locations.
Carbon monoxide detectors shall be installed in the locations specified in Clause 10.15.2.

These locations supersede the locations specified in ISO 72400.

10.15.5.3 Combination detectors.
Combination carbon monoxide/smoke detectors installed in carbon monoxide detection systems shall be an acceptable alternative to carbon monoxide detectors, provided that they are listed in accordance with this Code.

10.15.6 Maintenance.
Carbon monoxide alarms and carbon monoxide detection systems shall be maintained in accordance with the Ghana Fire Code.

10.16 GAS DETECTION SYSTEMS

10.16.1 Gas detection systems.
Gas detection systems required by this Code shall comply with Clauses 10.16.2 through 916.11.

10.16.2 Permits.
Permits shall be required as set forth in the Ghana Fire Code.

10.16.2.1 Construction documents.
Documentation of the gas detection system design and equipment to be used that demonstrates compliance with the requirements of this Code shall be provided with the application for permit.

10.16.3 Equipment.
Gas detection system equipment shall be designed for use with the gases being detected and shall be installed in accordance with manufacturer’s instructions.

10.16.4 Power connections.
Gas detection systems shall be permanently connected to the building electrical power supply or shall be permitted to be cord connected to an unswitched receptacle using an approved restraining means that secures the plug to the receptacle.

10.16.5 Emergency and standby power.
Standby or emergency power shall be provided or the gas detection system shall initiate a trouble signal at an approved location if the power supply is interrupted.

10.16.6 Sensor locations.
Sensors shall be installed in approved locations where leaking gases are expected to accumulate.
10.16.7 Gas sampling.
Gas sampling shall be performed continuously. Sample analysis shall be processed immediately after sampling, except as follows:

1. For HPM gases, sample analysis shall be performed at intervals not exceeding 30 minutes.
2. For toxic gases, sample analysis shall be performed at intervals not exceeding 5 minutes in accordance with the Ghana Fire Code.
3. Where a less frequent or delayed sampling interval is approved.

10.16.8 System activation.
A gas detection alarm shall be initiated where any sensor detects a concentration of gas exceeding the following thresholds:

1. For flammable gases, a gas concentration exceeding 25 percent of the lower flammability limit (LFL).
2. For nonflammable gases, a gas concentration exceeding one-half of the IDLH, unless a different threshold is specified by the clause of this Code requiring a gas detection system.

Upon activation of a gas detection alarm, alarm signals or other required responses shall be as specified by the clause of this Code requiring a gas detection system. Audible and visible alarm signals associated with a gas detection alarm shall be distinct from fire alarm and carbon monoxide alarm signals.

10.16.9 Signage.
Signs shall be provided adjacent to gas detection system alarm signaling devices that advise occupants of the nature of the signals and actions to take in response to the signal.

10.16.10 Fire alarm system connections.
Gas sensors and gas detection systems shall not be connected to fire alarm systems unless approved and connected in accordance with the fire alarm equipment manufacturer’s instructions.

10.16.11 Inspection, testing and sensor calibration.
Gas detection systems and sensors shall be inspected, tested and calibrated in accordance with the Ghana Fire Code.

10.17 MASS NOTIFICATION SYSTEMS

10.17.1 College and university campuses.
Prior to construction of a new building requiring a fire alarm system on a multiple-building college or university campus having a cumulative building occupant load of 1,000 or more, a mass notification risk analysis shall be conducted in accordance with ISO 7240. Where the risk analysis determines a need for mass notification, an approved mass notification system shall be provided in accordance with the findings of the risk analysis.

10.18 EMERGENCY RESPONDER RADIO COVERAGE

10.18.1 General.
Emergency responder radio coverage shall be provided in all new buildings in accordance with the Ghana Fire Code.
PART 11: MEANS OF ESCAPE

User notes:

About this part: Part 11 provides the general criteria for designing the means of escape established as the primary method for protection of people in buildings by allowing timely relocation or evacuation of building occupants. Both prescriptive and performance language is utilized in this part to provide for a basic approach in the determination of a safe exiting system for all occupancies. It addresses all portions of the escape system (exit access, exits and exit discharge) and includes design requirements as well as provisions regulating individual components. The requirements detail the size, arrangement, number and protection of means of escape components. Functional and operational characteristics that will permit the safe use of components without special knowledge or effort are specified.

The means of escape protection requirements work in coordination with other Clauses of the Code, such as protection of vertical openings (see Part 8), interior finish (see Part 9), fire suppression and detection systems (see Part 10) and numerous others, all having an impact on life safety. Part 11 is subdivided into four main Clauses: general (Clauses 11.3–11.15), exit access (Clauses 11.16–11.21), exit (Clauses 11.22–11.27) and exit discharge (Clause 11.28). Special allowances for the unique requirements for assembly spaces (Clause 11.29) and emergency escape and rescue openings (Clause 11.30) complete the part. Part 11 of this Code is duplicated in Part 10 of the Ghana Fire Code®; however, the Ghana Fire Code contains one additional Clause on maintenance of the means of Escape system in existing buildings.

11.1 ADMINISTRATION

11.1.1 General.

Buildings or portions thereof shall be provided with a means of escape system as required by this part. The provisions of this part shall control the design, construction and arrangement of means of escape components required to provide an approved means of escape from structures and portions thereof.

11.1.2 Minimum requirements.

It shall be unlawful to alter a building or structure in a manner that will reduce the number of exits or the minimum width or required capacity of the means of escape to less than required by this Code.

11.2 MAINTENANCE AND PLANS

11.2.1 Maintenance.

Means of escape shall be maintained in accordance with the Ghana Fire Code.

11.2.2 Fire safety and evacuation plans.

Fire safety and evacuation plans shall be provided for all occupancies and buildings where required by the Ghana Fire Code. Such fire safety and evacuation plans shall comply with the applicable provisions of the Ghana Fire Code.

11.3 GENERAL MEANS OF ESCAPE

11.3.1 Applicability.

The general requirements specified in Clauses 11.3 through 11.15 shall apply to all three elements of the means of escape system, in addition to those specific requirements for the exit access, the exit and the exit discharge detailed elsewhere in this part.

11.3.2 Ceiling height.

The means of escape shall have a ceiling height of not less than 2286 mm (7 feet 6 inches) above the finished floor.

Exceptions:

1. Sloped ceilings in accordance with this Code.
2. Ceilings of dwelling units and sleeping units within residential occupancies in accordance with this Code.
3. Allowable projections in accordance with Clause 11.3.3.
4. Stair headroom in accordance with Clause 11.11.3.
5. Door height in accordance with Clause 11.10.1.1.
6. Ramp headroom in accordance with Clause 11.12.5.2.
7. The clear height of floor levels in vehicular and pedestrian traffic areas of public and private parking garages in accordance with Clause 4.6.2.2.
8. Areas above and below mezzanine floors in accordance with Clause 6.8.2.
11.3.3 Protruding objects.

Protruding objects on circulation paths shall comply with the requirements of Clauses 11.3.3.1 through 11.3.3.4.

11.3.3.1 Headroom.

Protruding objects are permitted to extend below the minimum ceiling height required by Clause 11.3.2 where a minimum headroom of 2032 mm (80 inches) is provided over any circulation paths, including walks, corridors, aisles and passageways. Not more than 50 percent of the ceiling area of a means of escape shall be reduced in height by protruding objects.

Exception: Door closers and stops shall not reduce headroom to less than 1981 mm (78 inches).

A barrier shall be provided where the vertical clearance above a circulation path is less than 2032 mm (80 inches) high above the finished floor. The leading edge of such a barrier shall be located 686 mm (27 inches) maximum above the finished floor.

11.3.3.2 Post-mounted objects.

A free-standing object mounted on a post or pylon shall not overhang that post or pylon more than 102 mm (4 inches) where the lowest point of the leading edge is more than 686 mm (27 inches) and less than 2032 mm (80 inches) above the finished floor. Where a sign or other obstruction is mounted between posts or pylons and the clear distance between the posts or pylons is greater than 305 mm (12 inches), the lowest edge of such sign or obstruction shall be 686 mm (27 inches) maximum or 2032 mm (80 inches) minimum above the finished floor or ground.

Exception: These requirements shall not apply to sloping portions of handrails between the top and bottom riser of stairs and above the ramp run.

11.3.3.3 Horizontal projections.

Objects with leading edges more than 685 mm (27 inches) and not more than 2030 mm (80 inches) above the finished floor shall not project horizontally more than 102 mm (4 inches) into the circulation path.

Exception: Handrails are permitted to protrude 114 mm (41/2 inches) from the wall or guard.

11.3.3.4 Clear width.

Protruding objects shall not reduce the minimum clear width of accessible routes.

11.3.4 Slip-resistant surface.

Circulation paths of the means of escape shall have a slip-resistant surface and be securely attached.

11.3.5 Elevation change.

Where changes in elevation of less than 305 mm (12 inches) exist in the means of escape, sloped surfaces shall be used. Where the slope is greater than one unit vertical in 20 units horizontal (5-percent slope), ramps complying with Clause 11.12 shall be used. Where the difference in elevation is 152 mm (6 inches) or less, the ramp shall be equipped with either handrails or floor finish materials that contrast with adjacent floor finish materials.

Exceptions:

1. A single step with a maximum riser height of 178 mm (7 inches) is permitted for buildings with occupancies in Groups F, H, R-2, R-3, S and U at exterior doors not required to be accessible by Part 11.

2. A stair with a single riser or with two risers and a tread is permitted at locations not required to be accessible by Part 11 where the risers and treads comply with Clause 11.11.5, the minimum depth of the tread is 330 mm (13 inches) and not less than one handrail complying with Clause 11.14 is provided within 762 mm (30 inches) of the centreline of the normal path of escape travel on the stair.

3. A step is permitted in aisles serving seating that has a difference in elevation less than 305 mm (12 inches) at locations not required to be accessible by Part 12, provided that the risers and treads comply with Clause 11.29.14 and the aisle is provided with a handrail complying with Clause 11.29.16.

Throughout a storey in a Group I-2 occupancy, any change in elevation in portions of the means of Escape that serve nonambulatory persons shall be by means of a ramp or sloped walkway.
11.3.6 Means of Escape continuity.
The path of escape travel along a means of escape shall not be interrupted by a building element other than a means of escape component as specified in this part. Obstructions shall not be placed in the minimum width or required capacity of a means of escape component except projections permitted by this part. The minimum width or required capacity of a means of escape system shall not be diminished along the path of escape travel.

11.3.7 Elevators, escalators and moving walks.
Elevators, escalators and moving walks shall not be used as a component of a required means of escape from any other part of the building.

Exception: Elevators used as an accessible means of escape in accordance with Clause 11.9.4.

11.4 OCCUPANT LOAD
11.4.1 Design occupant load.
In determining means of escape requirements, the number of occupants for whom means of escape facilities are provided shall be determined in accordance with this Clause.

11.4.1.1 Methods of Measurement
The following methods of measurement apply specifically to B1. Other methods of measurement applicable more widely throughout this Document are given in the definitions in Appendix D, and illustrated in Appendix C.

(a) Occupant capacity of a:

(i) room or storey - is the maximum number of persons it is designed to hold (where this is known) or the number calculated (using the occupancy load factors given in Table 1.1) from - area of room or storey (m²) occupancy load factor

Note: ‘area’ excludes stairway enclosures, lifts and sanitary accommodation.

(ii) building or part of a building - is the sum of the number of occupants of the storeys in the building or part.

(b) Travel distance - is by way of the shortest route, which if:

(i) there is fixed seating or other fixed obstructions, is along the centre line of the seatways and gangways;

(ii) it includes a stairway, is along the pitch line on the centre line of travel.

(c) Width - The width of:

(i) a doorway is the clear width when the door or doors are open. Door hardware which does not intrude more than 100 mm into this width may be ignored. (see Figure 1);

Note: It is assumed that the door or doors are free to open to an angle of at least 90°.

(ii) an escape route is the width at 1500 mm above floor level when defined by walls (handrails fixed to walls which do not intrude more than 100 mm into this width may be ignored) or elsewhere the minimum width of passage available between any fixed obstructions; and

(iii) a stairway is the clear width between the walls or balustrades, (strings and handrails intruding not more than 30 mm and 100 mm respectively may be ignored).

11.4.2 Cumulative occupant loads.
Where the path of escape travel includes intervening rooms, areas or spaces, cumulative occupant loads shall be determined in accordance with this Clause.

11.4.2.1 Intervening spaces or accessory areas.
Where occupants escape from one or more rooms, areas or spaces through others, the design occupant load shall be the combined occupant load of interconnected accessory or intervening spaces. Design of escape path capacity shall be based on the cumulative portion of occupant loads of all rooms, areas or spaces to that point along the path of escape travel.

11.4.2.2 Adjacent levels for mezzanines.
That portion of the occupant load of a mezzanine with required escape through a room, area or space on an adjacent level shall
be added to the occupant load of that room, area or space.

11.4.2.3 Adjacent stories.

Other than for the escape components designed for convergence in accordance with Clause 11.5.6, the occupant load from separate stories shall not be added.

11.4.3 Multiple function occupant load.

Where an area under consideration contains multiple functions having different occupant load factors, the design occupant load for such area shall be based on the floor area of each function calculated independently.

11.4.4 Multiple occupancies.

Where a building contains two or more occupancies, the means of escape requirements shall apply to each portion of the building based on the occupancy of that space. Where two or more occupancies utilize portions of the same means of escape system, those escape components shall meet the more stringent requirements of all occupancies that are served.

11.4.5 Areas without fixed seating.

The number of occupants shall be computed at the rate of one occupant per unit of area as prescribed in Table 11.4.5. For areas without fixed seating, the occupant load shall be not less than that number determined by dividing the floor area under consideration by the occupant load factor assigned to the function of the space as set forth in Table 11.4.5. Where an intended function is not listed in Table 11.4.5, the building official shall establish a function based on a listed function that most nearly resembles the intended function.

Exception: Where approved by the building official, the actual number of occupants for whom each occupied space, floor or building is designed, although less than those determined by calculation, shall be permitted to be used in the determination of the design occupant load.

### TABLE 11.4.5

<table>
<thead>
<tr>
<th>MAXIMUM FLOOR AREA ALLOWANCES PER OCCUPANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function of Space</td>
</tr>
<tr>
<td>Accessory storage areas, mechanical equipment room</td>
</tr>
<tr>
<td>Agricultural building</td>
</tr>
<tr>
<td>Aircraft hangars</td>
</tr>
<tr>
<td>Airport terminal</td>
</tr>
<tr>
<td>Baggage claim</td>
</tr>
<tr>
<td>Baggage handling</td>
</tr>
<tr>
<td>Concourse</td>
</tr>
<tr>
<td>Waiting areas</td>
</tr>
<tr>
<td>Assembly</td>
</tr>
<tr>
<td>Gaming floors (keno, slots, etc.)</td>
</tr>
<tr>
<td>Exhibit gallery and museum</td>
</tr>
<tr>
<td>Assembly with fixed seats</td>
</tr>
<tr>
<td>Assembly without fixed seats</td>
</tr>
<tr>
<td>Concentrated (chairs only—not fixed)</td>
</tr>
<tr>
<td>Standing space</td>
</tr>
<tr>
<td>Unconcentrated (tables and chairs)</td>
</tr>
<tr>
<td>Bowling centers, allow 5 persons for each lane including 15 feet of runway, and for additional areas</td>
</tr>
<tr>
<td>Business areas</td>
</tr>
<tr>
<td>Concentrated business use areas</td>
</tr>
<tr>
<td>See Section 1004.8</td>
</tr>
<tr>
<td>Courtrooms—other than fixed seating areas</td>
</tr>
<tr>
<td>Day care</td>
</tr>
<tr>
<td>Dormitories</td>
</tr>
<tr>
<td>Educational</td>
</tr>
<tr>
<td>Classroom area</td>
</tr>
<tr>
<td>Shops and other vocational room areas</td>
</tr>
<tr>
<td>Exercise rooms</td>
</tr>
<tr>
<td>Group H-5 fabrication and manufacturing areas</td>
</tr>
<tr>
<td>Industrial areas</td>
</tr>
<tr>
<td>Institutional areas</td>
</tr>
<tr>
<td>Inpatient treatment areas</td>
</tr>
<tr>
<td>Outpatient areas</td>
</tr>
<tr>
<td>Sleeping areas</td>
</tr>
<tr>
<td>Kitchens, commercial</td>
</tr>
<tr>
<td>Library</td>
</tr>
<tr>
<td>Reading rooms</td>
</tr>
<tr>
<td>Stack area</td>
</tr>
<tr>
<td>Locker rooms</td>
</tr>
<tr>
<td>Mail buildings—covered and open</td>
</tr>
<tr>
<td>Mercantile</td>
</tr>
<tr>
<td>Storage, stock, shipping areas</td>
</tr>
<tr>
<td>300 gross</td>
</tr>
<tr>
<td>Parking garages</td>
</tr>
<tr>
<td>Residential</td>
</tr>
<tr>
<td>Skating rinks, swimming pools</td>
</tr>
<tr>
<td>Rink and pool</td>
</tr>
<tr>
<td>Decks</td>
</tr>
<tr>
<td>Stages and platforms</td>
</tr>
<tr>
<td>Warehouses</td>
</tr>
</tbody>
</table>

Note: For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m².

a. Floor area in square feet per occupant.

11.4.5.1 Increased occupant load.

The occupant load permitted in any building, or portion thereof, is permitted to be increased from that number established for the
occupancies in Table 11.4.5, provided that all other requirements of the Code are met based on such modified number and the occupant load does not exceed one occupant per 0.65 m² (7 square feet) of occupiable floor space. Where required by the building official, an approved aisle, seating or fixed equipment diagram substantiating any increase in occupant load shall be submitted. Where required by the building official, such diagram shall be posted.

11.4.6 Fixed seating.

For areas having fixed seats and aisles, the occupant load shall be determined by the number of fixed seats installed therein. The occupant load for areas in which fixed seating is not installed, such as waiting spaces, shall be determined in accordance with Clause 11.4.5 and added to the number of fixed seats.

The occupant load of wheelchair spaces and the associated companion seat shall be based on one occupant for each wheelchair space and one occupant for the associated companion seat provided in accordance with this Code.

For areas having fixed seating without dividing arms, the occupant load shall be not less than the number of seats based on one person for each 457 mm (18 inches) of seating length.

The occupant load of seating booths shall be based on one person for each 610 mm (24 inches) of booth seat length measured at the backrest of the seating booth.

11.4.7 Outdoor areas.

Yards, patios, occupied roofs, courts and similar outdoor areas accessible to and usable by the building occupants shall be provided with means of escape as required by this part. The occupant load of such outdoor areas shall be assigned by the building official in accordance with the anticipated use. Where outdoor areas are to be used by persons in addition to the occupants of the building, and the path of escape travel from the outdoor areas passes through the building, means of escape requirements for the building shall be based on the sum of the occupant loads of the building plus the outdoor areas.

Exceptions:

11.4.8 Concentrated business use areas.

The occupant load factor for concentrated business use shall be applied to telephone call centres, trading floors, electronic data processing centres and similar business use areas with a higher density of occupants than would normally be expected in a typical business occupancy environment. Where approved by the building official, the occupant load for concentrated business use areas shall be the actual occupant load, but not less than one occupant per 4.65 m² (50 square feet) of gross occupiable floor space.

11.4.9 Posting of occupant load.

Every room or space that is an assembly occupancy shall have the occupant load of the room or space posted in a conspicuous place, near the main exit or exit access doorway from the room or space, for the intended configurations. Posted signs shall be of an approved legible permanent design and shall be maintained by the owner or the owner's authorized agent.

11.5 MEANS OF ESCAPE SIZING

11.5.1 General.

All portions of the means of escape system shall be sized in accordance with this Clause.

Exception: Aisles and aisle access ways in rooms or spaces used for assembly purposes complying with Clause 11.29.

11.5.2 Minimum width based on component.

The minimum width, in mm (inches), of any means of escape components shall be not less than that specified for such component, elsewhere in this Code.
11.5.3 Required capacity based on occupant load.

The required capacity, in mm (inches), of the means of escape for any room, area, space or storey shall be not less than that determined in accordance with Clauses 11.5.3.1 and 11.5.3.2:

11.5.3.1 Stairways.

The capacity, in inches, of means of escape stairways shall be calculated by multiplying the occupant load served by such stairways by a means of escape capacity factor of 7.6 mm (0.3 inch) per occupant. Where stairways serve more than one storey, only the occupant load of each storey considered individually shall be used in calculating the required capacity of the stairways serving that storey.

Exceptions:

1. For other than Group H and I-2 occupancies, the capacity, in inches, of means of escape stairways shall be calculated by multiplying the occupant load served by such stairways by a means of escape capacity factor of 5.1 mm (0.2 inch) per occupant in buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and an emergency voice/alarm communication system in accordance with Clause 10.7.5.2.2.

2. Facilities with smoke-protected assembly seating shall be permitted to use the capacity factors in Table 11.29.6.2 indicated for level or ramped aisles for means of escape components other than stairways where the entire path for means of escape from the seating to the exit discharge is provided with a smoke control system complying with Clause 10.9.

3. Facilities with open-air assembly seating shall be permitted to the capacity factors in Clause 11.29.6.3 indicated for stepped aisles for exit access or exit stairways where the entire path for means of escape from the seating to the exit discharge is open to the outdoors.

11.5.3.2 Other Escape components.

The capacity, in inches, of means of escape components other than stairways shall be calculated by multiplying the occupant load served by such component by a means of escape capacity factor of 5.1 mm (0.2 inch) per occupant.

Exceptions:

1. For other than Group H and I-2 occupancies, the capacity, in inches, of means of escape components other than stairways shall be calculated by multiplying the occupant load served by such component by a means of escape capacity factor of 3.8 mm (0.15 inch) per occupant in buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and an emergency voice/alarm communication system in accordance with Clause 10.7.5.2.2.

2. Facilities with smoke-protected assembly seating shall be permitted to use the capacity factors in Table 11.29.6.2 indicated for level or ramped aisles for means of escape components other than stairways where the entire path for means of escape from the seating to the exit discharge is provided with a smoke control system complying with Clause 10.9.

3. Facilities with open-air assembly seating shall be permitted to the capacity factors in Clause 11.29.6.3 indicated for level or ramped aisles for means of escape components other than stairways where the entire path for means of escape from the seating to the exit discharge is open to the outdoors.

11.5.4 Continuity.

The minimum width or required capacity of the means of escape required from any storey of a building shall not be reduced along the path of escape travel until arrival at the public way.
11.5.5 Distribution of minimum width and required capacity.

Where more than one exit, or access to more than one exit, is required, the means of escape shall be configured such that the loss of any one exit, or access to one exit, shall not reduce the available capacity or width to less than 50 percent of the required capacity or width.

11.5.6 Escape convergence.

Where the means of escape from stories above and below converge at an intermediate level, the capacity of the means of escape from the point of convergence shall be not less than the largest minimum width or the sum of the required capacities for the stairways or ramps serving the two adjacent stories, whichever is larger.

11.5.7 Encroachment.

Encroachments into the required means of escape width shall be in accordance with the provisions of this Clause.

11.5.7.1 Doors.

Doors, when fully opened, shall not reduce the required width by more than 178 mm (7 inches). Doors in any position shall not reduce the required width by more than one-half.

Exceptions:

1. Surface-mounted latch release hardware shall be exempt from inclusion in the 178 mm (7-inch maximum) encroachment where both of the following conditions exist:
   1.1. The hardware is mounted to the side of the door facing away from the adjacent wall where the door is in the open position.
   1.2. The hardware is mounted not less than 865 mm (34 inches) nor more than 1219 mm (48 inches) above the finished floor.

2. The restrictions on door swing shall not apply to doors within individual dwelling units and sleeping units of Group R-2 occupancies and dwelling units of Group R-3 occupancies.

11.5.7.2 Other projections.

Handrail projections shall be in accordance with the provisions of Clause 11.14.8. Other nonstructural projections such as trim and similar decorative features shall be permitted to project into the required width not more than 38 mm (11/2 inches) on each side.

Exception: Projections are permitted in corridors within Group I-2 Condition 1 in accordance with Clause 4.7.4.3.

11.5.7.3 Protruding objects.

Protruding objects shall comply with the applicable requirements of Clause 11.3.3.

11.6 NUMBER OF EXITS AND EXIT ACCESS DOORWAYS

11.6.1 General.

The number of exits or exit access doorways required within the means of escape system shall comply with the provisions of Clause 11.6.2 for spaces, including mezzanines, and Clause 11.6.3 for stories or occupied roofs.

11.6.2 Escape from spaces.

Rooms, areas or spaces, including mezzanines, within a storey or basement shall be provided with the number of exits or access to exits in accordance with this Clause.

11.6.2.1 Escape based on occupant load and common path of Escape travel distance.

Two exits or exit access doorways from any space shall be provided where the design occupant load or the common path of Escape travel distance exceeds the values listed in Table 11.6.2.1. The cumulative occupant load from adjacent rooms, areas or spaces shall be determined in accordance with Clause 11.4.2.

1. The number of exits from foyers, lobbies, vestibules or similar spaces need not be based on cumulative occupant loads for areas discharging through such spaces, but the capacity of the exits from such spaces shall be based on applicable cumulative occupant loads.
2. Care suites in Group I-2 occupancies complying with Clause 4.7.4.

### TABLE 11.6.2.1

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>MAXIMUM OCCUPANT LOAD OF SPACE</th>
<th>MAXIMUM COMMON PATH OF ESCAPE TRAVEL DISTANCE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without Sprinkler System</td>
<td>With Sprinkler System</td>
</tr>
<tr>
<td></td>
<td>(feet)</td>
<td>(feet)</td>
</tr>
<tr>
<td>OL ≤ 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OL &gt; 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A, E, M</td>
<td>49</td>
<td>75</td>
</tr>
<tr>
<td>B</td>
<td>49</td>
<td>100</td>
</tr>
<tr>
<td>F</td>
<td>49</td>
<td>75</td>
</tr>
<tr>
<td>H-1, H-2, H-3</td>
<td>3</td>
<td>NP</td>
</tr>
<tr>
<td>H-4, H-5</td>
<td>10</td>
<td>NP</td>
</tr>
<tr>
<td>I-1, I-2, I-4</td>
<td>10</td>
<td>NP</td>
</tr>
<tr>
<td>I-3</td>
<td>10</td>
<td>NP</td>
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<tr>
<td>R-1</td>
<td>10</td>
<td>NP</td>
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<tr>
<td>R-2</td>
<td>20</td>
<td>NP</td>
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<tr>
<td>R-3</td>
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<td>NP</td>
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<td>R-4</td>
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<td>NP</td>
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<tr>
<td>S</td>
<td>29</td>
<td>100</td>
</tr>
<tr>
<td>U</td>
<td>49</td>
<td>100</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 foot = 304.8 mm.

NP = Not Permitted.

- a. Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2. See Clause 10.3 for occupancies where automatic sprinkler systems are permitted in accordance with Clause 10.3.3.1.2.
- b. Group H occupancies equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.5. For the travel distance limitations in Group I-2, see Clause 4.7.4.
- c. For a room or space used for assembly purposes having fixed seating, see Clause 11.29.8.
- d. For the travel distance limitations in Group R-3 and R-4 equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.3, see Clause 11.6.2.2.6.
- e. The common path of Escape travel distance shall only apply in a Group R-3 occupancy located in a mixed occupancy building.
- f. The length of common path of Escape travel distance in a Group S-2 open parking garage shall be not more than 100 feet.
- g. For the travel distance limitations in Groups R-3 and R-4 equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.3, see Clause 11.6.2.2.6.

#### 11.6.2.1.1 Three or more exits or exit access doorways.

Three exits or exit access doorways shall be provided from any space with an occupant load of 501 to 1,000. Four exits or exit access doorways shall be provided from any space with an occupant load greater than 1,000.

#### 11.6.2.2 Escape based on use.

The numbers of exits or access to exits shall be provided in the uses described in Clauses 11.6.2.2.1 through 11.6.2.2.6.

### 11.6.2.2.1 Boiler, incinerator and furnace rooms.

Two exit access doorways are required in boiler, incinerator and furnace rooms where the area is over 46 m² (500 square feet) and any fuel-fired equipment exceeds 422 000 KJ (400,000 British thermal units (Btu)) input capacity. Where two exit access doorways are required, one is permitted to be a fixed ladder or an alternating tread device. Exit access...
doorways shall be separated by a horizontal distance equal to one-half the length of the maximum overall diagonal dimension of the room.

11.6.2.2 Refrigeration machinery rooms.
Machinery rooms larger than 93 m² (1,000 square feet) shall have not less than two exits or exit access doorways. Where two exit access doorways are required, one such doorway is permitted to be served by a fixed ladder or an alternating tread device. Exit access doorways shall be separated by a horizontal distance equal to one-half the maximum horizontal dimension of the room.

All portions of machinery rooms shall be within 45 720 mm (150 feet) of an exit or exit access doorway. An increase in exit access travel distance is permitted in accordance with Clause 11.17.1.

Exit and exit access doorways shall swing in the direction of escape travel, regardless of the occupant load served. Exit and exit access doorways shall be tight fitting and self-closing.

11.6.2.2.3 Refrigerated rooms or spaces.
Rooms or spaces having a floor area larger than 93 m² (1,000 square feet), containing a refrigerant evaporator and maintained at a temperature below 20°C (68°F), shall have access to not less than two exits or exit access doorways.

Exit access travel distance shall be determined as specified in Clause 11.17.1, but all portions of a refrigerated room or space shall be within 45 720 mm (150 feet) of an exit or exit access doorway where such rooms are not protected by an approved automatic sprinkler system. Escape is allowed through adjoining refrigerated rooms or spaces.

Exception: Where using refrigerants in quantities limited to the amounts based on the volume set forth in the International Mechanical Code.

11.6.2.2.4 Group I-4 means of Escape.
Group I-4 facilities, rooms or spaces where care is provided for more than 10 children that are 21/2 years of age or less, shall have access to not less than two exits or exit access doorways.

11.6.2.2.5 Vehicular ramps.
Vehicular ramps shall not be considered as an exit access ramp unless pedestrian facilities are provided.

11.6.2.2.6 Groups R-3 and R-4.
Where Group R-3 occupancies are permitted by Clause 10.3.2.8 to be protected by an automatic sprinkler system installed in accordance with Clause 10.3.3.1, the exit access travel distance for Group R-3 shall be not more than 38 100 mm (125 feet). Where Group R-4 occupancies are permitted by Clause 10.3.2.8 to be protected by an automatic sprinkler system installed in accordance with Clause 10.3.3.1, the exit access travel distance for Group R-4 shall be not more than 22 860 mm (75 feet).

11.6.3 Escape from stories or occupied roofs.
The means of escape system serving any storey or occupied roof shall be provided with the number of separate and distinct exits or access to exits based on the aggregate occupant load served in accordance with this Clause. Where stairways serve more than one storey, only the occupant load of each storey considered individually shall be used in calculating the required number of exits or access to exits serving that storey.

11.6.3.1 Adjacent storey.
The path of escape travel to an exit shall not pass through more than one adjacent storey.

Exception: The path of escape travel to an exit shall be permitted to pass through more than one adjacent storey in any of the following:

1. In Group R-1, R-2 or R-3 occupancies, exit access stairways and ramps connecting four stories or less serving and contained within an individual dwelling unit, sleeping unit or live/work unit.

2. Exit access stairways serving and contained within a Group R-3 congregate residence or a Group R-4 facility.

3. Exit access stairways and ramps in open parking garages that serve only the parking garage.
4. Exit access stairways and ramps serving open-air assembly seating complying with the exit access travel distance requirements of Clause 11.29.7.

5. Exit access stairways and ramps between the balcony, gallery or press box and the main assembly floor in occupancies such as theaters, places of religious worship, auditoriums and sports facilities.

11.6.3.2 Escape based on occupant load.

Each storey and occupied roof shall have the minimum number of separate and distinct exits, or access to exits, as specified in Table 11.6.3.2. A single exit or access to a single exit shall be permitted in accordance with Clause 11.6.3.3. The required number of exits, or exit access stairways or ramps providing access to exits, from any storey or occupied roof shall be maintained until arrival at the exit discharge or a public way.

### TABLE 11.6.3.2

<table>
<thead>
<tr>
<th>Minimum Number of Exits or Access to Exits Per Storey</th>
<th>Minimum Number of Exits or Access to Exits Per Storey</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE 11.6.3.2 MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS PER STOREY</td>
<td>TABLE 11.6.3.2 MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS PER STOREY</td>
</tr>
</tbody>
</table>

### 11.6.3.3 Single exits.

A single exit or access to a single exit shall be permitted from any storey or occupied roof where one of the following conditions exists:

1. The occupant load, number of dwelling units and common path of escape travel distance do not exceed the values in Table 11.6.3.3(1) or 11.6.3.3(2).

2. Rooms, areas and spaces complying with Clause 11.6.2.1 with exits that discharge directly to the exterior at the level of exit discharge, are permitted to have one exit or access to a single exit.

3. Parking garages where vehicles are mechanically parked shall be permitted to have one exit or access to a single exit.

4. Group R-3 and R-4 occupancies shall be permitted to have one exit or access to a single exit.

5. Individual single-storey or multistorey dwelling units shall be permitted to have a single exit or access to a single exit from the dwelling unit provided that both of the following criteria are met:

   5.1. The dwelling unit complies with Clause 11.6.2.1 as a space with one means of escape.

   5.2. Either the exit from the dwelling unit discharges directly to the exterior at the level of exit discharge, or the exit access outside the dwelling unit’s entrance door provides access to not less than two approved independent exits.
### TABLE 11.6.3.3(1) STORIES WITH ONE EXIT OR ACCESS TO ONE EXIT FOR R-2 OCCUPANCIES

<table>
<thead>
<tr>
<th>STOREY</th>
<th>OCCUPANCY</th>
<th>MAXIMUM NUMBER OF DWELLING UNITS</th>
<th>MAXIMUM COMMON PATH OF ESCAPE TRAVEL DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basement, first, second or third storey above grade plane</td>
<td>R-2&lt;sup&gt;a, b&lt;/sup&gt;</td>
<td>4 dwelling units</td>
<td>125 feet</td>
</tr>
<tr>
<td>Fourth storey above grade plane and higher</td>
<td>NP</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 foot = 304.8 mm.
NP = Not Permitted.
NA = Not Applicable.

- a. Buildings classified as Group R-2 equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and provided with emergency escape and rescue openings in accordance with Clause 11.30.
- b. This table is used for R-2 occupancies consisting of dwelling units. For R-2 occupancies consisting of sleeping units, use Table 11.6.3.3(2).

### TABLE 11.6.3.3(2) STORIES WITH ONE EXIT OR ACCESS TO ONE EXIT FOR OTHER OCCUPANCIES

<table>
<thead>
<tr>
<th>STOREY</th>
<th>OCCUPANCY</th>
<th>MAXIMUM OCCUPANT LOAD PER STOREY</th>
<th>MAXIMUM COMMON PATH OF ESCAPE TRAVEL DISTANCE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First storey above or below grade plane</td>
<td>A, B&lt;sup&gt;a&lt;/sup&gt;, E, F&lt;sup&gt;b&lt;/sup&gt;, M, U</td>
<td>49</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>H-2, H-3</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>H-4, H-5, I, R-1, R-2&lt;sup&gt;a, c&lt;/sup&gt;</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>S&lt;sup&gt;b, c&lt;/sup&gt;</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>Second storey above grade plane</td>
<td>B, F, M, S&lt;sup&gt;d&lt;/sup&gt;</td>
<td>29</td>
<td>75</td>
</tr>
<tr>
<td>Third storey above grade plane and higher</td>
<td>NP</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 foot = 304.8 mm.
NP = Not Permitted.
NA = Not Applicable.

- a. Buildings classified as Group R-2 equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 and provided with emergency escape and rescue openings in accordance with Clause 11.30.
- b. Group B, F and S occupancies in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 shall have a maximum exit access travel distance of 100 feet.
- c. This table is used for R-2 occupancies consisting of dwelling units. For R-2 occupancies consisting of sleeping units, use Table 11.6.3.3(2).
- d. The length of exit access travel distance in a Group S-2 open parking garage shall be not more than 100 feet.

### 11.6.3.3.1 Mixed occupancies.

Where one exit, or exit access stairway or ramp providing access to exits at other stories, is permitted to serve individual stories, mixed occupancies shall be permitted to be served by single exits provided each individual occupancy complies with the applicable requirements of Table 11.6.3.3(1) or 11.6.3.3(2) for that occupancy. Where applicable, cumulative occupant loads from adjacent occupancies shall be considered to be in accordance with the provisions of Clause 11.4.1. In each storey of a mixed occupancy building, the maximum number of occupants served by a single exit shall be such that the sum of the ratios of the calculated number of occupants of the space divided by the allowable number of occupants indicated in Table 11.6.3.3(2) for each occupancy does not exceed one. Where dwelling units are located on a storey with other occupancies, the actual number of dwelling units divided by four plus the ratio from the other occupancy does not exceed one.

### 11.7 EXIT AND EXIT ACCESS DOORWAY CONFIGURATION

#### 11.7.1 General.

Exits, exit access doorways, and exit access stairways and ramps serving spaces, including individual building stories, shall be separated in accordance with the provisions of this Clause.

#### 11.7.1.1 Two exits or exit access doorways.
Where two exits, exit access doorways, exit access stairways or ramps, or any combination thereof, are required from any portion of the exit access, they shall be placed a distance apart equal to not less than one-half of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between them. Interlocking or scissor stairways shall be counted as one exit stairway.

**Exceptions:**

1. Where interior exit stairways or ramps are interconnected by a 1-hour fire-resistance-rated corridor conforming to the requirements of Clause 11.20, the required exit separation shall be measured along the shortest direct line of travel within the corridor.

2. Where a building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, the separation distance shall be not less than one-third of the length of the maximum overall diagonal dimension of the area served.

**11.7.1.1.1 Measurement point.**

The separation distance required in Clause 11.7.1.1 shall be measured in accordance with the following:

1. The separation distance to exit or exit access doorways shall be measured to any point along the width of the doorway.

2. The separation distance to exit access stairways shall be measured to the closest riser.

3. The separation distance to exit access ramps shall be measured to the start of the ramp run.

**11.7.1.2 Three or more exits or exit access doorways.**

Where access to three or more exits is required, not less than two exit or exit access stairways shall be arranged in accordance with the provisions of Clause 11.7.1.1. Additional required exit or exit access stairways shall be arranged a reasonable distance apart so that if one becomes blocked, the others will be available.

**11.7.1.3 Remoteness of exit access stairways or ramps.**

Where two exit access stairways or ramps provide the required means of escape to exits at another storey, the required separation distance shall be maintained for all portions of such exit access stairways or ramps.

**11.7.1.3.1 Three or more exit access stairways or ramps.**

Where more than two exit access stairways or ramps provide the required means of escape, not less than two shall be arranged in accordance with Clause 11.7.1.3.

**11.8 MEANS OF ESCAPE ILLUMINATION**

**11.8.1 Means of Escape illumination.**

Illumination shall be provided in the means of escape in accordance with Clause 11.8.2. Under emergency power, means of escape illumination shall comply with Clause 11.8.3.

**11.8.2 Illumination required.**

The means of escape serving a room or space shall be illuminated at all times that the room or space is occupied.

**Exceptions:**

1. Occupancies in Group U.

2. Aisle accessways in Group A.

3. Dwelling units and sleeping units in Groups R-1, R-2 and R-3.

4. Sleeping units of Group I occupancies.

**11.8.2.1 Illumination level under normal power.**

The means of escape illumination level shall be not less than 11 lux (1 footcandle) at the walking surface.

**Exception:** For auditoriums, theaters, concert or opera halls and similar assembly occupancies, the illumination at the walking
surface is permitted to be reduced during performances by one of the following methods provided that the required illumination is automatically restored upon activation of a premises' fire alarm system:

1. Externally illuminated walking surfaces shall be permitted to be illuminated to not less than 2.15 lux (0.2 footcandle).
2. Steps, landings and the sides of ramps shall be permitted to be marked with self-luminous materials in accordance with Clauses 11.25.2.1, 11.25.2.2 and 11.25.2.4 by systems listed in accordance with this Code.

11.8.2.2 Group I-2.

In Group I-2 occupancies where two or more exits are required, on the exterior landings required by Clause 11.10.1.6, means of escape illumination levels for the exit discharge shall be provided such that failure of a single lamp in a luminaire shall not reduce the illumination level on that landing to less than 11 lux (1 footcandle).

11.8.2.3 Exit discharge.

Illumination shall be provided along the path of travel for the exit discharge from each exit to the public way.

Exception: Illumination shall not be required where the path of the exit discharge meets both of the following requirements:

1. The path of exit discharge is illuminated from the exit to a safe dispersal area complying with Clause 11.28.5.
2. A dispersal area shall be illuminated to a level not less than 11 lux (1 footcandle) at the walking surface.

11.8.3 Emergency power for illumination.

The power supply for means of escape illumination shall normally be provided by the premises' electrical supply.

11.8.3.1 General.

In the event of power supply failure in rooms and spaces that require two or more means of escape, an emergency electrical system shall automatically illuminate all of the following areas:

1. Aisles.
2. Corridors.
3. Exit access stairways and ramps.

11.8.3.2 Buildings.

In the event of power supply failure in buildings that require two or more means of escape, an emergency electrical system shall automatically illuminate all of the following areas:

1. Interior exit access stairways and ramps.
2. Interior and exterior exit stairways and ramps.
3. Exit passageways.
4. Vestibules and areas on the level of discharge used for exit discharge in accordance with Clause 11.28.1.
5. Exterior landings as required by Clause 11.10.1.6 for exit doorways that lead directly to the exit discharge.

11.8.3.3 Rooms and spaces.

In the event of power supply failure, an emergency electrical system shall automatically illuminate all of the following areas:

1. Electrical equipment rooms.
2. Fire command centres.
3. Fire pump rooms.
4. Generator rooms.
5. Public restrooms with an area greater than 27.87 m² (300 square feet).

11.8.3.4 Duration.

The emergency power system shall provide power for a duration of not less than 90 minutes and shall consist of storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with Clause 28.13.
11.8.3.5 Illumination level under emergency power.

Emergency lighting facilities shall be arranged to provide initial illumination that is not less than an average of 11 lux (1 footcandle) and a minimum at any point of 1 lux (0.1 footcandle) measured along the path of escape at floor level. Illumination levels shall be permitted to decline to 6 lux (0.6 footcandle) average and a minimum at any point of 0.6 lux (0.06 footcandle) at the end of the emergency lighting time duration. A maximum-to-minimum illumination uniformity ratio of 40 to 1 shall not be exceeded. In Group I-2 occupancies, failure of a single lamp in a luminaire shall not reduce the illumination level to less than 2.2 lux (0.2 footcandle).

11.9 ACCESSIBLE MEANS OF ESCAPE

11.9.1 Accessible means of Escape required.

Accessible means of escape shall comply with this Clause. Accessible spaces shall be provided with not less than one accessible means of escape. Where more than one means of escape is required by Clause 11.6.2 or 11.6.3 from any accessible space, each accessible portion of the space shall be served by not less than two accessible means of escape.

Exceptions:

1. One accessible means of escape is required from an accessible mezzanine level in accordance with Clause 11.9.3, 11.9.4 or 11.9.5.

2. In assembly areas with ramped aisles or stepped aisles, one accessible means of escape is permitted where the common path of escape travel is accessible and meets the requirements in Clause 11.29.8.

11.9.2 Continuity and components.

Each required accessible means of escape shall be continuous to a public way and shall consist of one or more of the following components:

1. Accessible routes complying with this Code.

2. Interior exit stairways complying with Clauses 11.9.3 and 11.23.

3. Exit access stairways complying with Clauses 11.9.3 and 11.19.3 or 11.19.4.

4. Exterior exit stairways complying with Clauses 11.9.3 and 11.27 and serving levels other than the level of exit discharge.

5. Elevators complying with Clause 11.9.4.

6. Platform lifts complying with Clause 11.9.5.


8. Ramps complying with Clause 11.12.


10. Exterior areas for assisted rescue complying with Clause 11.9.7 serving exits at the level of exit discharge.

11.9.2.1 Elevators required.

In buildings where a required accessible floor is four or more stories above or below a level of exit discharge, not less than one required accessible means of escape shall be an elevator complying with Clause 11.9.4.

Exceptions:

1. In buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, the elevator shall not be required on floors provided with a horizontal exit and located at or above the levels of exit discharge.

2. In buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, the elevator shall not be required on floors provided with a ramp conforming to the provisions of Clause 11.12.

11.9.3 Stairways.

In order to be considered part of an accessible means of escape, a stairway between stories
shall comply with Clauses 11.9.3.1 through 11.9.3.3.

11.9.3.1 Exit access stairways.

Exit access stairways that connect levels in the same storey are not permitted as part of an accessible means of escape.

**Exception:** Exit access stairways providing means of escape from mezzanines are permitted as part of an accessible means of escape.

11.9.3.2 Stairway width.

Stairways shall have a clear width of 1219 mm (48 inches) minimum between handrails.

**Exceptions:**

1. The clear width of 1219 mm (48 inches) between handrails is not required in buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

2. The clear width of 1219 mm (48 inches) between handrails is not required for stairways accessed from a refuge area in conjunction with a horizontal exit.

11.9.3.3 Area of refuge.

Stairways shall either incorporate an area of refuge within an enlarged floor-level landing or shall be accessed from an area of refuge complying with Clause 11.9.6.

**Exceptions:**

1. Areas of refuge are not required at exit access stairways where two-way communication is provided at the elevator landing in accordance with Clause 11.9.8.

2. Areas of refuge are not required at stairways in buildings equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

3. Areas of refuge are not required at stairways serving open parking garages.

4. Areas of refuge are not required for smoke-protected or open-air assembly seating areas complying with Clauses 11.29.6.2 and 11.29.6.3.

5. Areas of refuge are not required at stairways in Group R-2 occupancies.

6. Areas of refuge are not required for stairways accessed from a refuge area in conjunction with a horizontal exit.

11.9.4 Elevators.

In order to be considered part of an accessible means of escape, an elevator shall comply with Clauses 11.9.4.1 and 11.9.4.2.

11.9.4.1 Standby power.

The elevator shall meet the emergency operation and signaling device requirements of Clause 2.27 of ASME A17.1/CSA B44. Standby power shall be provided in accordance with this Code.

11.9.4.2 Area of refuge.

The elevator shall be accessed from an area of refuge complying with Clause 11.9.6.

**Exceptions:**

1. Areas of refuge are not required at the elevator in open parking garages.

2. Areas of refuge are not required in buildings and facilities equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

3. Areas of refuge are not required at elevators not required to be located in a shaft in accordance with Clause 8.12.

4. Areas of refuge are not required at elevators serving smoke-protected or open-air assembly seating areas complying with Clauses 11.29.6.2 and 11.29.6.3.

5. Areas of refuge are not required for elevators accessed from a refuge area in conjunction with a horizontal exit.
11.9.5 Platform lifts.

Platform lifts shall be permitted to serve as part of an accessible means of escape where allowed as part of a required accessible route in Clause 12.09.8 except for Item 10. Standby power for the platform lift shall be provided in accordance with this Code.

11.9.6 Areas of refuge.

Every required area of refuge shall be accessible from the space it serves by an accessible means of escape.

11.9.6.1 Travel distance.

The maximum travel distance from any accessible space to an area of refuge shall not exceed the exit access travel distance permitted for the occupancy in accordance with Clause 11.17.1.

11.9.6.2 Stairway or elevator access.

Every required area of refuge shall have direct access to a stairway complying with Clauses 11.9.3 and 11.23 or an elevator complying with Clause 11.9.4.

11.9.6.3 Size.

Each area of refuge shall be sized to accommodate one wheelchair space of 762 mm by 1219 mm (30 inches by 48 inches) for each 200 occupants or portion thereof, based on the occupant load of the area of refuge and areas served by the area of refuge. Such wheelchair spaces shall not reduce the means of Escape minimum width or required capacity. Access to any of the required wheelchair spaces in an area of refuge shall not be obstructed by more than one adjoining wheelchair space.

11.9.6.4 Separation.

Each area of refuge shall be separated from the remainder of the storey by a smoke barrier complying with Clause 8.9 or a horizontal exit complying with Clause 11.26. Each area of refuge shall be designed to minimize the intrusion of smoke.

Exceptions:

1. Areas of refuge located within an enclosure for interior exit stairways complying with Clause 11.23.

2. Areas of refuge in outdoor facilities where exit access is essentially open to the outside.

11.9.6.5 Two-way communication.

Areas of refuge shall be provided with a two-way communication system complying with Clauses 11.9.8.1 and 11.9.8.2.

11.9.7 Exterior areas for assisted rescue.

Exterior areas for assisted rescue shall be accessed by an accessible route from the area served.

Where the exit discharge does not include an accessible route from an exit located on the level of exit discharge to a public way, an exterior area of assisted rescue shall be provided on the exterior landing in accordance with Clauses 11.9.7.1 through 11.9.7.4.

11.9.7.1 Size.

Each exterior area for assisted rescue shall be sized to accommodate wheelchair spaces in accordance with Clause 11.9.6.3.

11.9.7.2 Separation.

Exterior walls separating the exterior area of assisted rescue from the interior of the building shall have a minimum fire-resistance rating of 1 hour, rated for exposure to fire from the inside. The fire-resistance-rated exterior wall construction shall extend horizontally not less than 3048 mm (10 feet) beyond the landing on either side of the landing or equivalent fire-resistance-rated construction is permitted to extend out perpendicular to the exterior wall not less than 1220 mm (4 feet) on the side of the landing. The fire-resistance-rated construction shall extend vertically from the ground to a point not less than 3048 mm (10 feet) above the floor level of the area for assisted rescue or to the roof line, whichever is lower. Openings within such fire-resistance-rated exterior walls shall be protected in accordance with Clause 8.16.

Exception: The fire-resistance rating and opening protectives are not required in the exterior wall where the building is equipped
throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

11.9.7.3 Openness.

The exterior area for assisted rescue shall be open to the outside air. The sides other than the separation walls shall be not less than 50 percent open, and the open area shall be distributed so as to minimize the accumulation of smoke or toxic gases.

11.9.7.4 Stairways.

Stairways that are part of the means of escape for the exterior area for assisted rescue shall provide a minimum clear width of 1220 mm (48 inches) between handrails.

Exception: The minimum clear width of 1220 mm (48 inches) between handrails is not required at stairways serving buildings equipped with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

11.9.8 Two-way communication.

A two-way communication system complying with Clauses 11.9.8.1 and 11.9.8.2 shall be provided at the landing serving each elevator or bank of elevators on each accessible floor that is one or more stories above or below the level of exit discharge.

Exceptions:

1. Two-way communication systems are not required at the landing serving each elevator or bank of elevators where the two-way communication system is provided within areas of refuge in accordance with Clause 11.9.6.5.

2. Two-way communication systems are not required on floors provided with ramps conforming to the provisions of Clause 11.12.

3. Two-way communication systems are not required at the landings serving only service elevators that are not designated as part of the accessible means of escape or serve as part of the required accessible route into a facility.

4. Two-way communication systems are not required at the landings serving only freight elevators.

5. Two-way communication systems are not required at the landing serving a private residence elevator.

6. Two-way communication systems are not required in Group I-2 or I-3 facilities.

11.9.8.1 System requirements.

Two-way communication systems shall provide communication between each required location and the fire command center or a central control point location approved by the fire department. Where the central control point is not a constantly attended location, a two-way communication system shall have a timed automatic telephone dial-out capability to a monitoring location or 9-1-1. The two-way communication system shall include both audible and visible signals.

11.9.8.2 Directions.

Directions for the use of the two-way communication system, instructions for summoning assistance via the two-way communication system and written identification of the location shall be posted adjacent to the two-way communication system. Signage shall comply with the ICC A117.1 requirements for visual characters.

11.9.9 Signage.

Signage indicating special accessibility provisions shall be provided as shown:

1. Each door providing access to an area of refuge from an adjacent floor area shall be identified by a sign stating: AREA OF REFUGE.

2. Each door providing access to an exterior area for assisted rescue shall be identified by a sign stating: EXTERIOR AREA FOR ASSISTED RESCUE.

Signage shall comply with the ICC A117.1 requirements for visual characters and include the International Symbol of Accessibility.
exit sign illumination is required by Clause 11.13.3, the signs shall be illuminated. Additionally, visual characters, raised character and braille signage complying with ICC A117.1 shall be located at each door to an area of refuge and exterior area for assisted rescue in accordance with Clause 11.13.4.

11.9.10 Directional signage.
Directional signage indicating the location of all other means of escape and which of those are accessible means of escape shall be provided at the following:
1. At exits serving a required accessible space but not providing an approved accessible means of escape.
2. At elevator landings.
3. Within areas of refuge.

11.9.11 Instructions.
In areas of refuge and exterior areas for assisted rescue, instructions on the use of the area under emergency conditions shall be posted. Signage shall comply with the ICC A117.1 requirements for visual characters. The instructions shall include all of the following:
1. Persons able to use the exit stairway do so as soon as possible, unless they are assisting others.
2. Information on planned availability of assistance in the use of stairs or supervised operation of elevators and how to summon such assistance.
3. Directions for use of the two-way communication system where provided.

11.10 DOORS, GATES AND TURNSTILES

11.10.1 Doors.
Means of escape doors shall meet the requirements of this Clause. Doors serving a means of escape system shall meet the requirements of this Clause and Clause 11.22.2. Doors provided for escape purposes in numbers greater than required by this Code shall meet the requirements of this Clause.

Means of escape doors shall be readily distinguishable from the adjacent construction and finishes such that the doors are easily recognizable as doors. Mirrors or similar reflecting materials shall not be used on means of escape doors. Means of escape doors shall not be concealed by curtains, drapes, decorations or similar materials.

11.10.1.1 Size of doors.
The required capacity of each door opening shall be sufficient for the occupant load thereof and shall provide a minimum clear opening width of 813 mm (32 inches). The clear opening width of doorways with swinging doors shall be measured between the face of the door and the stop, with the door open 90 degrees (1.57 rad). Where this Clause requires a minimum clear opening width of 813 mm (32 inches) and a door opening includes two door leaves without a mullion, one leaf shall provide a minimum clear opening width of 813 mm (32 inches) and a door opening includes two door leaves without a mullion, one leaf shall provide a minimum clear opening width of 813 mm (32 inches). In Group I-2, doors serving as means of escape where used for the movement of beds shall provide a minimum clear opening width of 1054 mm (41 1/2 inches). The maximum width of a swinging door leaf shall be 1219 mm (48 inches) nominal. The minimum clear opening height of doors shall be not less than 2032 mm (80 inches).

Exceptions:
1. In Group R-2 and R-3 dwelling and sleeping units that are not required to be an Accessible unit, Type A unit or Type B unit, the minimum and maximum width shall not apply to door openings that are not part of the required means of escape.
2. In Group I-3, door openings to resident sleeping units that are not required to be an Accessible unit shall have a minimum clear opening width of 711 mm (28 inches).
3. Door openings to storage closets less than 0.93 m2 (10 square feet) in area shall not be limited by the minimum clear opening width.
4. The width of door leaves in revolving doors that comply with Clause 11.10.1.4.1 shall not be limited.
5. The maximum width of door leaves in power-operated doors that comply
with Clause 11.10.1.4.2 shall not be limited.

6. Door openings within a dwelling unit or sleeping unit shall have a minimum clear opening height of 1981 mm (78 inches).

7. In dwelling and sleeping units that are not required to be Accessible, Type A or Type B units, exterior door openings other than the required exit door shall have a minimum clear opening height of 1930 mm (76 inches).

8. In Groups I-1, R-2, R-3 and R-4, in dwelling and sleeping units that are not required to be Accessible, Type A or Type B units, the minimum clear opening widths shall not apply to interior escape doors.

9. Door openings required to be accessible within Type B units intended for user passage shall have a minimum clear opening width of 806 mm (31.75 inches).

10. Doors to walk-in freezers and coolers less than 93 m2 (1,000 square feet) in area shall have a maximum width of 1524 mm (60 inches) nominal.

11. The minimum clear opening width shall not apply to doors for nonaccessible shower or sauna compartments.

12. The minimum clear opening width shall not apply to the doors for nonaccessible toilet stalls.

### 11.10.1.2 Door swing.

Escape doors shall be of the pivoted or side-hinged swinging type.

**Exceptions:**

1. Private garages, office areas, factory and storage areas with an occupant load of 10 or less.

2. Group I-3 occupancies used as a place of detention.

3. Critical or intensive care patient rooms within suites of health care facilities.

4. Doors within or serving a single dwelling unit in Groups R-2 and R-3.

5. In other than Group H occupancies, revolving doors complying with Clause 11.10.1.4.1.

6. In other than Group H occupancies, special purpose horizontal sliding, accordion or folding door assemblies complying with Clause 11.10.1.4.3.

7. Power-operated doors in accordance with Clause 11.10.1.4.2.

8. Doors serving a bathroom within an individual sleeping unit in Group R-1.

9. In other than Group H occupancies, manually operated horizontal sliding doors are permitted in a means of Escape from spaces with an occupant load of 10 or less.

#### 11.10.1.1.1 Projections into clear width.

There shall not be projections into the required clear opening width lower than 864 mm (34 inches) above the floor or ground. Projections into the clear opening width between 864 mm (34 inches) and 2032 mm (80 inches) above the floor or ground shall not exceed 102 mm (4 inches).

**Exception:** Door closers and door stops shall be permitted to be 1980 mm (78 inches) minimum above the floor.

#### 11.10.1.2 Direction of swing.

Pivot or side-hinged swinging doors shall swing in the direction of Escape travel where serving a room or area containing an occupant load of 50 or more persons or a Group H occupancy.

#### 11.10.1.3 Door opening force.

The force for pushing or pulling open interior swinging Escape doors, other than fire doors, shall not exceed 22 N (5 pounds). These forces do not apply to the force required to retract latch bolts or disengage other devices that hold the door in a closed position. For other swinging doors, as well as sliding and folding doors, the door latch shall release when subjected to a 67 N (15-pound) force. The door shall be set in motion when subjected to a 133
N (30-pound) force. The door shall swing to a full-open position when subjected to a 67 N (15-pound) force.

11.10.1.3.1 Location of applied forces.

Forces shall be applied to the latch side of the door.

11.10.1.4 Special doors.

Special doors and security grilles shall comply with the requirements of Clauses 11.10.1.4.1 through 11.10.1.4.5.

11.10.1.4.1 Revolving doors.

Revolving doors shall comply with the following:

1. Revolving doors shall comply with this Code and shall be installed in accordance with the manufacturer’s instructions.

2. Each revolving door shall be capable of breakout in accordance with this Code and shall provide an aggregate width of not less than 914 mm (36 inches).

3. A revolving door shall not be located within 3048 mm (10 feet) of the foot or top of stairways or escalators. A dispersal area shall be provided between the stairways or escalators and the revolving doors.

4. The revolutions per minute (rpm) for a revolving door shall not exceed the maximum rpm as specified in this Code. Manual revolving doors shall comply with Table 11.10.1.4.1(1). Automatic or power-operated revolving doors shall comply with Table 11.10.1.4.1(2).

5. An emergency stop switch shall be provided near each entry point of power or automatic operated revolving doors within 48 inches (1220 mm) of the door and between 610 mm (24 inches) and 1220 mm (48 inches) above the floor. The activation area of the emergency stop switch button shall be not less than 25 mm (1 inch) in diameter and shall be red.

6. Each revolving door shall have a side-hinged swinging door that complies with Clause 11.10.1 in the same wall and within 3048 mm (10 feet) of the revolving door.

7. Revolving doors shall not be part of an accessible route required by Clause 11.9 and Part 12.

### TABLE 11.10.1.4.1(1) MAXIMUM DOOR SPEED MANUAL REVOLVING DOORS

<table>
<thead>
<tr>
<th>REVOLVING DOOR NOMINAL DIAMETER (FT-IN)</th>
<th>MAXIMUM ALLOWABLE REVOLVING DOOR SPEED (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-0</td>
<td>12</td>
</tr>
<tr>
<td>7-0</td>
<td>11</td>
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<tr>
<td>8-0</td>
<td>10</td>
</tr>
<tr>
<td>9-0</td>
<td>9</td>
</tr>
<tr>
<td>10-0</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

### TABLE 11.10.1.4.1(2) MAXIMUM DOOR SPEED AUTOMATIC OR POWER-OPERATED REVOLVING DOORS

<table>
<thead>
<tr>
<th>REVOLVING DOOR NOMINAL DIAMETER (FT-IN)</th>
<th>MAXIMUM ALLOWABLE REVOLVING DOOR SPEED (RPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-0</td>
<td>7.2</td>
</tr>
<tr>
<td>9-0</td>
<td>6.4</td>
</tr>
<tr>
<td>10-0</td>
<td>5.7</td>
</tr>
<tr>
<td>11-0</td>
<td>5.2</td>
</tr>
<tr>
<td>12-0</td>
<td>4.8</td>
</tr>
<tr>
<td>12-6</td>
<td>4.6</td>
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<tr>
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<td>3.6</td>
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<td>3.2</td>
</tr>
<tr>
<td>20-0</td>
<td>2.9</td>
</tr>
<tr>
<td>24-0</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

11.10.1.4.1.1 Escape component.

A revolving door used as a component of a means of escape shall comply with Clause 11.10.1.4.1 and the following three conditions:
1. Revolving doors shall not be given credit for more than 50 percent of the minimum width or required capacity.

2. Each revolving door shall be credited with a capacity based on not more than a 50-person occupant load.

3. Each revolving door shall provide for Escape in accordance with this Code, with a breakout force of not more than 578 N (130 pounds).

11.10.1.4.1.2 Other than Escape component.

A revolving door used as other than a component of a means of escape shall comply with Clause 11.10.1.4.1. The breakout force of a revolving door not used as a component of a means of escape shall not be more than 801 N (180 pounds).

Exception: A breakout force in excess of 801 N (180 pounds) is permitted if the breakout force is reduced to not more than 578 N (130 pounds) when not less than one of the following conditions is satisfied:

1. There is a power failure or power is removed to the device holding the door wings in position.

2. There is an actuation of the automatic sprinkler system where such system is provided.

3. There is an actuation of a smoke detection system that is installed in accordance with Clause 10.7 to provide coverage in areas within the building that are within 22860 mm (75 feet) of the revolving doors.

4. There is an actuation of a manual control switch, in an approved location and clearly identified, that reduces the breakout force to not more than 578 N (130 pounds).

11.10.1.4.2 Power-operated doors.

Where means of escape doors are operated or assisted by power, the design shall be such that in the event of power failure, the door is capable of being opened manually to permit means of escape travel or closed where necessary to safeguard means of escape. The forces required to open these doors manually shall not exceed those specified in Clause 11.10.1.3, except that the force to set the door in motion shall not exceed 220 N (50 pounds). The door shall be capable of opening from any position to the full width of the opening in which such door is installed when a force is applied to the door on the side from which escape is made. Power-operated swinging doors, power-operated sliding doors and power-operated folding doors shall comply with this code. Power-assisted swinging doors and low-energy power-operated swinging doors shall comply with this Code. Low-energy power-operated sliding doors and low-energy power-operated folding doors shall comply with this Code.

Exceptions:

1. Occupancies in Group I-3.

2. Special purpose horizontal sliding, accordion or folding doors complying with Clause 11.10.1.4.3.

3. For a biparting door in the emergency breakout mode, a door leaf located within a multiple-leaf opening shall be exempt from the minimum 813 mm (32-inch) single-leaf requirement of Clause 11.10.1.1, provided that a minimum 813 mm (32-inch) clear opening is provided when the two biparting leaves meeting in the center are broken out.

11.10.1.4.3 Special purpose horizontal sliding, accordion or folding doors.

In other than Group H occupancies, special purpose horizontal sliding, accordion or folding door assemblies permitted to be a component of a means of escape in accordance with Exception 6 to Clause 11.10.1.2 shall comply with all of the following criteria:

1. The doors shall be powered operated and shall be capable of being operated manually in the event of power failure.

2. The doors shall be openable by a simple method from both sides without special knowledge or effort.

3. The force required to operate the door shall not exceed 133 N (30 pounds) to set the door in motion and 67 N (15 pounds) to close the door or open it to the minimum required width.
4. The door shall be openable with a force not to exceed 67 N (15 pounds) when a force of 1100 N (250 pounds) is applied perpendicular to the door adjacent to the operating device.

5. The door assembly shall comply with the applicable fire protection rating and, where rated, shall be self-closing or automatic closing by smoke detection in accordance with Clause 8.16.2.6.6, shall be installed in accordance with the Ghana Fire Code and shall comply with Clause 8.16.

6. The door assembly shall have an integrated standby power supply.

7. The door assembly power supply shall be electrically supervised.

8. The door shall open to the minimum required width within 10 seconds after activation of the operating device.

11.10.1.4.4 Locking arrangements in educational occupancies.

In Group E and Group B educational occupancies, escape doors from classrooms, offices and other occupied rooms shall be permitted to be provided with locking arrangements designed to keep intruders from entering the room where all of the following conditions are met:

1. The door shall be capable of being unlocked from outside the room with a key or other approved means.

2. The door shall be openable from within the room in accordance with Clause 11.10.1.9.

3. Modifications shall not be made to listed panic hardware, fire door hardware or door closers.

11.10.1.4.4.1 Remote operation of locks.

Remote operation of locks complying with Clause 11.10.1.4.4 shall be permitted.

11.10.1.4.5 Security grilles.

In Groups B, F, M and S, horizontal sliding or vertical security grilles are permitted at the main exit and shall be openable from the inside without the use of a key or special knowledge or effort during periods that the space is occupied. The grilles shall remain secured in the full-open position during the period of occupancy by the general public. Where two or more means of escape are required, not more than one-half of the exits or exit access doorways shall be equipped with horizontal sliding or vertical security grilles.

11.10.1.5 Floor elevation.

There shall be a floor or landing on each side of a door. Such floor or landing shall be at the same elevation on each side of the door. Landings shall be level except for exterior landings, which are permitted to have a slope not to exceed 0.25 unit vertical in 12 units horizontal (2-percent slope).

Exceptions:

1. Doors serving individual dwelling units in Groups R-2 and R-3 where the following apply:

   1.1. A door is permitted to open at the top step of an interior flight of stairs, provided that the door does not swing over the top step.

   1.2. Screen doors and storm doors are permitted to swing over stairs or landings.

2. Exterior doors as provided for in Clause 11.3.5, Exception 1, and Clause 11.22.2, which are not on an accessible route.

3. In Group R-3 occupancies not required to be Accessible units, Type A units or Type B units, the landing at an exterior doorway shall be not more than 73/4 inches (197 mm) below the top of the threshold, provided the door, other than an exterior storm or screen door, does not swing over the landing.

4. Variations in elevation due to differences in finish materials, but not more than 12.7 mm (1/2 inch).

5. Exterior decks, patios or balconies that are part of Type B dwelling units, have impervious surfaces and that are not more than 102 mm (4
inches) below the finished floor level of the adjacent interior space of the dwelling unit.

6. Doors serving equipment spaces not required to be accessible in accordance with Clause 12.03.2.9 and serving an occupant load of five or less shall be permitted to have a landing on one side to be not more than 178 mm (7 inches) above or below the landing on the escape side of the door.

11.10.1.6 Landings at doors.

Landings shall have a width not less than the width of the stairway or the door, whichever is greater. Doors in the fully open position shall not reduce a required dimension by more than 178 mm (7 inches). Where a landing serves an occupant load of 50 or more, doors in any position shall not reduce the landing to less than one-half its required width. Landings shall have a length measured in the direction of travel of not less than 1118 mm (44 inches).

Exception: Landing length in the direction of travel in Groups R-3 and U and within individual units of Group R-2 need not exceed 914 mm (36 inches).

11.10.1.7 Thresholds.

Thresholds at doorways shall not exceed 19.1 mm (3/4 inch) in height above the finished floor or landing for sliding doors serving dwelling units or 12.7 mm (1/2 inch) above the finished floor or landing for other doors. Raised thresholds and floor level changes greater than 6.4 mm (1/4 inch) at doorways shall be beveled with a slope not greater than one unit vertical in two units horizontal (50-percent slope).

Exceptions:

1. In occupancy Group R-2 or R-3, threshold heights for sliding and side-hinged exterior doors shall be permitted to be up to 197 mm (73/4 inches) in height if all of the following apply:

1.1. The door is not part of the required means of escape.

1.2. The door is not part of an accessible route as required by Part 12.

1.3. The door is not part of an Accessible unit, Type A unit or Type B unit.

2. In Type B units, where Exception 5 to Clause 11.10.1.5 permits a 102 mm (4-inch) elevation change at the door, the threshold height on the exterior side of the door shall not exceed 120 mm (43/4 inches) in height above the exterior deck, patio or balcony for sliding doors or 114 mm (41/2 inches) above the exterior deck, patio or balcony for other doors.

11.10.1.8 Door arrangement.

Space between two doors in a series shall be 1219 mm (48 inches) minimum plus the width of a door swinging into the space. Doors in a series shall swing either in the same direction or away from the space between the doors.

Exceptions:

1. The minimum distance between horizontal sliding power-operated doors in a series shall be 1219 mm (48 inches).

2. Storm and screen doors serving individual dwelling units in Groups R-2 and R-3 need not be spaced 1219 mm (48 inches) from the other door.

3. Doors within individual dwelling units in Groups R-2 and R-3 other than within Type A dwelling units.

11.10.1.9 Door operations.

Except as specifically permitted by this Clause, Escape doors shall be readily openable from the Escape side without the use of a key or special knowledge or effort.

11.10.1.9.1 Hardware.

Door handles, pulls, latches, locks and other operating devices on doors required to be accessible by Part 12 shall not require tight grasping, tight pinching or twisting of the wrist to operate.
11.10.1.9.2 Hardware height.

Door handles, pulls, latches, locks and other operating devices shall be installed 864 mm (34 inches) minimum and 1219 mm (48 inches) maximum above the finished floor. Locks used only for security purposes and not used for normal operation are permitted at any height.

Exception: Access doors or gates in barrier walls and fences protecting pools, spas and hot tubs shall be permitted to have operable parts of the latch release on self-latching devices at 1370 mm (54 inches) maximum above the finished floor or ground, provided that the self-latching devices are not also self-locking devices operated by means of a key, electronic opener or integral combination lock.

11.10.1.9.3 Monitored or recorded Escape.

Where electrical systems that monitor or record Escape activity are incorporated, the locking system shall comply with Clause 11.10.1.9.7, 11.10.1.9.8, 11.10.1.9.9, 11.10.1.9.10 or 11.10.1.9.11 or shall be readily openable from the Escape side without the use of a key or special knowledge or effort.

11.10.1.9.4 Locks and latches.

Locks and latches shall be permitted to prevent operation of doors where any of the following exist:

1. Places of detention or restraint.

2. In buildings in occupancy Group A having an occupant load of 300 or less, Groups B, F, M and S, and in places of religious worship, the main door or doors are permitted to be equipped with key-operated locking devices from the Escape side provided:

   2.1. The locking device is readily distinguishable as locked.

   2.2. A readily visible durable sign is posted on the Escape side on or adjacent to the door stating: THIS DOOR TO REMAIN_UNLOCKED WHEN THIS SPACE IS OCCUPIED. The sign shall be in letters 1 inch (25 mm) high on a contrasting background.

2.3. The use of the key-operated locking device is revocable by the building official for due cause.

3. Where Escape doors are used in pairs, approved automatic flush bolts shall be permitted to be used, provided that the door leaf having the automatic flush bolts does not have a doorknob or surface-mounted hardware.

4. Doors from individual dwelling or sleeping units of Group R occupancies having an occupant load of 10 or less are permitted to be equipped with a night latch, dead bolt or security chain, provided such devices are openable from the inside without the use of a key or tool.

5. Fire doors after the minimum elevated temperature has disabled the unlatching mechanism in accordance with listed fire door test procedures.

6. Doors serving roofs not intended to be occupied shall be permitted to be locked preventing entry to the building from the roof.

1. 11.10.1.9.5 Bolt locks.

2. Manually operated flush bolts or surface bolts are not permitted.

Exceptions:

1. On doors not required for escape in individual dwelling units or sleeping units.

2. Where a pair of doors serves a storage or equipment room, manually operated edge- or surface-mounted bolts are permitted on the inactive leaf.

3. Where a pair of doors serves an occupant load of less than 50 persons in a Group B, F or S occupancy, manually operated edge- or surface-mounted bolts are permitted on the inactive leaf. The inactive leaf shall not contain doorknobs, panic bars or similar operating hardware.

4. Where a pair of doors serves a Group B, F or S occupancy, manually
operated edge- or surface-mounted bolts are permitted on the inactive leaf provided that such inactive leaf is not needed to meet Escape capacity requirements and the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1. The inactive leaf shall not contain doorknobs, panic bars or similar operating hardware.

5. Where a pair of doors serves patient care rooms in Group I-2 occupancies, self-latching edge- or surface-mounted bolts are permitted on the inactive leaf provided that the inactive leaf is not needed to meet Escape capacity requirements and the inactive leaf shall not contain doorknobs, panic bars or similar operating hardware.

11.10.1.9.6 Unlatching.

The unlatching of any door or leaf shall not require more than one operation.

Exceptions:

1. Places of detention or restraint.
2. Where manually operated bolt locks are permitted by Clause 11.10.1.9.5.
3. Doors with automatic flush bolts as permitted by Clause 11.10.1.9.4, Item 3.
4. Doors from individual dwelling units and sleeping units of Group R occupancies as permitted by Clause 11.10.1.9.4, Item 4.

11.10.1.9.6.1 Closet doors.

Closet doors that latch in the closed position shall be openable from inside the closet.

11.10.1.9.7 Controlled Escape doors in Groups I-1 and I-2.

Electric locking systems, including electromagnetic locking systems, shall be permitted to be locked in the means of Escape in Group I-1 or I-2 occupancies where the clinical needs of persons receiving care require their containment. Controlled Escape doors shall be permitted in such occupancies where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or an approved automatic smoke or heat detection system installed in accordance with Clause 10.7, provided that the doors are installed and operate in accordance with all of the following:

1. The door locks shall unlock on actuation of the automatic sprinkler system or automatic fire detection system.
2. The door locks shall unlock on loss of power controlling the lock or lock mechanism.
3. The door locking system shall be installed to have the capability of being unlocked by a switch located at the fire command center, a nursing station or other approved location. The switch shall directly break power to the lock.
4. A building occupant shall not be required to pass through more than one door equipped with a controlled Escape locking system before entering an exit.
5. The procedures for unlocking the doors shall be described and approved as part of the emergency planning and preparedness required by the Ghana Fire Code.
6. All clinical staff shall have the keys, Codes or other means necessary to operate the locking systems.
7. Emergency lighting shall be provided at the door.
8. The door locking system units shall be listed in accordance with this Code.

Exceptions:

1. Items 1 through 4 shall not apply to doors to areas occupied by persons who, because of clinical needs, require restraint or containment as part of the function of a psychiatric treatment area.
2. Items 1 through 4 shall not apply to doors to areas where a listed Escape control system is utilized to reduce the risk of child abduction from nursery and obstetric areas of a Group I-2 hospital.

11.10.1.9.8 Delayed Escape.

Delayed Escape locking systems shall be permitted to be installed on doors serving the following occupancies in buildings that are equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or an approved automatic smoke or heat detection system installed in accordance with Clause 10.7.

2. Group E classrooms with an occupant load of less than 50.

Exception: Delayed Escape locking systems shall be permitted to be installed on exit or exit access doors, other than the main exit or exit access door, serving a courtroom in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

11.10.1.9.8.1 Delayed Escape locking system.

The delayed escape locking system shall be installed and operated in accordance with all of the following:

1. The delay electronics of the delayed escape locking system shall deactivate upon actuation of the automatic sprinkler system or automatic fire detection system, allowing immediate free escape.
2. The delay electronics of the delayed escape locking system shall deactivate upon loss of power controlling the lock or lock mechanism, allowing immediate free Escape.
3. The delayed escape locking system shall have the capability of being deactivated at the fire command center and other approved locations.

4. An attempt to escape shall initiate an irreversible process that shall allow such escape in not more than 15 seconds when a physical effort to exit is applied to the escape side door hardware for not more than 3 seconds. Initiation of the irreversible process shall activate an audible signal in the vicinity of the door. Once the delay electronics have been deactivated, rearming the delay electronics shall be by manual means only.

Exception: Where approved, a delay of not more than 30 seconds is permitted on a delayed Escape door.

5. The Escape path from any point shall not pass through more than one delayed Escape locking system.

Exceptions:

1. In Group I-2 or I-3 occupancies, the Escape path from any point in the building shall pass through not more than two delayed Escape locking systems provided that the combined delay does not exceed 30 seconds.
2. In Group I-1 or I-4 occupancies, the Escape path from any point in the building shall pass through not more than two delayed Escape locking systems provided the combined delay does not exceed 30 seconds and the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

6. A sign shall be provided on the door and shall be located above and within 12 inches (305 mm) of the door exit hardware:

6.1. For doors that swing in the direction of Escape, the sign shall read: PUSH UNTIL ALARM SOUNDS. DOOR CAN BE OPENED IN 15 [30] SECONDS.

6.2. For doors that swing in the opposite direction of escape, the sign shall read: PULL UNTIL ALARM SOUNDS. DOOR CAN BE OPENED IN 15 [30] SECONDS.
6.3. The sign shall comply with the visual character requirements in ICC A117.1.

**Exception:** Where approved, in Group I occupancies, the installation of a sign is not required where care recipients who because of clinical needs require restraint or containment as part of the function of the treatment area.

7. Emergency lighting shall be provided on the escape side of the door.

8. The delayed Escape locking system units shall be listed in accordance with this Code.

### 11.10.1.9.9 Sensor release of electrically locked Escape doors.

Sensor release of electric locking systems shall be permitted on doors located in the means of escape in any occupancy except Group H where installed and operated in accordance with all of the following criteria:

1. The sensor shall be installed on the escape side, arranged to detect an occupant approaching the doors, and shall cause the electric locking system to unlock.

2. The electric locks shall be arranged to unlock by a signal from or loss of power to the sensor.

3. Loss of power to the lock or locking system shall automatically unlock the electric locks.

4. The doors shall be arranged to unlock from a manual unlocking device located 11.16 mm to 1219 mm (40 inches to 48 inches) vertically above the floor and within 1524 mm (5 feet) of the secured doors. Ready access shall be provided to the manual unlocking device and the device shall be clearly identified by a sign that reads “PUSH TO EXIT.” When operated, the manual unlocking device shall result in direct interruption of power to the electric lock—-independent of other electronics—and the electric lock shall remain unlocked for not less than 30 seconds.

5. Activation of the building fire alarm system, where provided, shall automatically unlock the electric lock, and the electric lock shall remain unlocked until the fire alarm system has been reset.

6. Activation of the building automatic sprinkler system or fire detection system, where provided, shall automatically unlock the electric lock. The electric lock shall remain unlocked until the fire alarm system has been reset.

7. The door locking system units shall be listed in accordance with this Code.

### 11.10.1.9.10 Door hardware release of electrically locked escape doors.

Door hardware release of electric locking systems shall be permitted on doors in the means of escape in any occupancy except Group H where installed and operated in accordance with all of the following:

1. The door hardware that is affixed to the door leaf has an obvious method of operation that is readily operated under all lighting conditions.

2. The door hardware is capable of being operated with one hand and shall comply with Clause 11.10.1.9.6.

3. Operation of the door hardware directly interrupts the power to the electric lock and unlocks the door immediately.

4. Loss of power to the electric locking system automatically unlocks the door.

5. Where panic or fire exit hardware is required by Clause 11.10.1.10, operation of the panic or fire exit hardware also releases the electric lock.

6. The locking system units shall be listed in accordance with this Code.

### 11.10.1.9.11 Locking arrangements in buildings within correctional facilities.

In buildings within correctional and detention facilities, doors in means of Escape serving rooms or spaces occupied by persons whose movements are controlled for security reasons shall be permitted to be locked where equipped
with Escape control devices that shall unlock manually and by not less than one of the following means:

1. Activation of an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.
2. Activation of an approved manual fire alarm box.
3. A signal from a constantly attended location.

11.10.1.9.12 Stairway doors.

Interior stairway means of Escape doors shall be openable from both sides without the use of a key or special knowledge or effort.

Exceptions:

1. Stairway discharge doors shall be openable from the Escape side and shall only be locked from the opposite side.
2. This Clause shall not apply to doors arranged in accordance with Clause 4.3.5.3.
3. Stairway exit doors are permitted to be locked from the side opposite the escape side, provided that they are openable from the escape side and capable of being unlocked simultaneously without unlatching upon a signal from the fire command center, if present, or a signal by emergency personnel from a single location inside the main entrance to the building.
4. Stairway exit doors shall be openable from the escape side and shall only be locked from the opposite side in Group B, F, M and S occupancies where the only interior access to the tenant space is from a single exit stairway where permitted in Clause 11.6.3.3.

11.10.1.10 Panic and fire exit hardware.

Swinging doors serving a Group H occupancy and swinging doors serving rooms or spaces with an occupant load of 50 or more in a Group A or E occupancy shall not be provided with a latch or lock other than panic hardware or fire exit hardware.

Exceptions:

1. A main exit of a Group A occupancy shall be permitted to have locking devices in accordance with Clause 11.10.1.9.4, Item 2.
2. Doors provided with panic hardware or fire exit hardware and serving a Group A or E occupancy shall be permitted to be electrically locked in accordance with Clause 11.10.1.9.9 or 11.10.1.9.10.

Electrical rooms with equipment rated 1,200 amperes or more and over 1829 mm (6 feet) wide, and that contain overcurrent devices, switching devices or control devices with exit or exit access doors, shall be equipped with panic hardware or fire exit hardware. The doors shall swing in the direction of escape travel.

11.10.1.10.1 Installation.

Where panic or fire exit hardware is installed, it shall comply with the following:

1. Panic hardware shall be listed in accordance with this Code.
2. Fire exit hardware shall be listed in accordance with this Code.
3. The actuating portion of the releasing device shall extend not less than one-half of the door leaf width.
4. The maximum unlatching force shall not exceed 67 N (15 pounds).

11.10.1.10.2 Balanced doors.

If balanced doors are used and panic hardware is required, the panic hardware shall be the push-pad type and the pad shall not extend more than one-half the width of the door measured from the latch side.
11.10.2 Gates.

Gates serving the means of escape system shall comply with the requirements of this Clause. Gates used as a component in a means of escape shall conform to the applicable requirements for doors.

Exception: Horizontal sliding or swinging gates exceeding the 1219 mm (4-foot) maximum leaf width limitation are permitted in fences and walls surrounding a stadium.

11.10.2.1 Stadiums.

Panic hardware is not required on gates surrounding stadiums where such gates are under constant immediate supervision while the public is present, and where safe dispersal areas based on 0.28 m² (3 square feet) per occupant are located between the fence and enclosed space. Such required safe dispersal areas shall not be located less than 15 240 mm (50 feet) from the enclosed space. See Clause 11.28.5 for means of Escape from safe dispersal areas.

11.10.3 Turnstiles and similar devices.

Turnstiles or similar devices that restrict travel to one direction shall not be placed so as to obstruct any required means of escape, except where permitted in accordance with Clauses 11.10.3.1, 11.10.3.2 and 11.10.3.3.

11.10.3.1 Capacity.

Each turnstile or similar device shall be credited with a capacity based on not more than a 50-person occupant load where all of the following provisions are met:

1. Each device shall turn free in the direction of escape travel when primary power is lost and on the manual release by an employee in the area.
2. Such devices are not given credit for more than 50 percent of the required escape capacity or width.
3. Each device is not more than 991 mm (39 inches) high.
4. Each device has not less than 419 mm (161/2 inches) clear width at and below a height of 991 mm (39 inches) and not less than 559 mm (22 inches) clear width at heights above 991 mm (39 inches).

11.10.3.1.1 Clear width.

Where located as part of an accessible route, turnstiles shall have not less than 914 mm (36 inches) clear at and below a height of 864 mm (34 inches), not less than 813 mm (32 inches) clear width between 864 mm (34 inches) and 2032 mm (80 inches) and shall consist of a mechanism other than a revolving device.

11.10.3.2 Security access turnstiles.

Security access turnstiles that inhibit travel in the direction of escape utilizing a physical barrier shall be permitted to be considered as a component of the means of escape, provided that all of the following criteria are met:

1. The building is protected throughout by an automatic sprinkler system in accordance with Clause 10.3.3.1.1.
2. Each security access turnstile lane configuration has a minimum clear passage width of 559 mm (22 inches).
3. Any security access turnstile lane configuration providing a clear passage width of less than 810 mm (32 inches) shall be credited with a maximum escape capacity of 50 persons.
4. Any security access turnstile lane configuration providing a clear passage width of 810 mm (32 inches) or more shall be credited with a maximum escape capacity as calculated in accordance with Clause 11.5.
5. Each secured physical barrier shall automatically retract or swing to an unobstructed open position in the direction of escape, under each of the following conditions:

5.1. Upon loss of power to the turnstile or any part of the access control system that secures the physical barrier.
5.2. Upon actuation of a clearly identified manual release device with ready access that results in direct interruption of power to each
secured physical barrier, after which such barriers remain in the open position for not less than 30 seconds. The manual release device shall be positioned at one of the following locations:

5.2.1. On the escape side of each security access turnstile lane.

5.2.2. At an approved location where it can be actuated by an employee assigned to the area at all times that the building is occupied.

5.3. Upon actuation of the building fire alarm system, if provided, after which the physical barrier remains in the open position until the fire alarm system is manually reset.

**Exception:** Actuation of a manual fire alarm box.

5.4. Upon actuation of the building automatic sprinkler or fire detection system, after which the physical barrier remains in the open position until the fire alarm system is manually reset.

11.10.3.3 High turnstile.

Turnstiles more than 991 mm (39 inches) high shall meet the requirements for revolving doors or the requirements of Clause 11.10.3.2 for security access turnstiles.

11.10.3.4 Additional door.

Where serving an occupant load greater than 300, each turnstile that is not portable shall have a side-hinged swinging door that conforms to Clause 11.10.1 within 15 240 mm (50 feet).

**Exception:** A side-hinged swinging door is not required at security access turnstiles that comply with Clause 11.10.3.2

11.11 STAIRWAYS

11.11.1 General.

Stairways serving occupied portions of a building shall comply with the requirements of Clauses 11.11.2 through 11.11.13. Alternating tread devices shall comply with Clause 11.11.14. Ships ladders shall comply with Clause 11.11.15. Ladders shall comply with Clause 11.11.16.

**Exception:** Within rooms or spaces used for assembly purposes, stepped aisles shall comply with Clause 11.29.

11.11.2 Width and capacity.

The required capacity of stairways shall be determined as specified in Clause 11.5.1, but the minimum width shall be not less than 1118 mm (44 inches). See Clause 11.9.3 for accessible means of escape stairways.

**Exceptions:**

1. Stairways serving an occupant load of less than 50 shall have a width of not less than 914 mm (36 inches).

2. Spiral stairways as provided for in Clause 11.11.10.

3. Where an incline platform lift or stairway chairlift is installed on stairways serving occupancies in Group R-3, or within dwelling units in occupancies in Group R-2, a clear passage width not less than 508 mm (20 inches) shall be provided. Where the seat and platform can be folded when not in use, the distance shall be measured from the folded position.

11.11.3 Headroom.

Stairways shall have a headroom clearance of not less than 2032 mm (80 inches) measured vertically from a line connecting the edge of the nosings. Such headroom shall be continuous above the stairway to the point where the line intersects the landing below, one tread depth beyond the bottom riser. The minimum clearance shall be maintained the full width of the stairway and landing.

**Exceptions:**

1. Spiral stairways complying with Clause 11.11.10 are permitted a 1981 mm (78-inch) headroom clearance.

2. In Group R-3 occupancies; within dwelling units in Group R-2 occupancies; and in Group U occupancies that are accessory to a Group R-3 occupancy or...
accessory to individual dwelling units in Group R-2 occupancies; where the nosings of treads at the side of a flight extend under the edge of a floor opening through which the stair passes, the floor opening shall be allowed to project horizontally into the required headroom not more than 121 mm (43/4 inches).

11.11.4 Walkline.

The walkline across winder treads shall be concentric to the direction of travel through the turn and located 12 inches (305 mm) from the side where the winders are narrower. The 12-inch (305 mm) dimension shall be measured from the widest point of the clear stair width at the walking surface of the winder. Where winders are adjacent within the flight, the point of the widest clear stair width of the adjacent winders shall be used.

11.11.5 Stair treads and risers.

Stair treads and risers shall comply with Clauses 11.11.5.1 through 11.11.5.3.

11.11.5.1 Dimension reference surfaces.

For the purpose of this Clause, all dimensions are exclusive of carpets, rugs or runners.

11.11.5.2 Riser height and tread depth.

Stair riser heights shall be 178 mm (7 inches) maximum and 102 mm (4 inches) minimum. The riser height shall be measured vertically between the nosings of adjacent treads. Rectangular tread depths shall be 279 mm (11 inches) minimum measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread’s nosing. Winder treads shall have a minimum tread depth of 279 mm (11 inches) between the vertical planes of the foremost projection of adjacent treads at the interClauses with the walkline and a minimum tread depth of 254 mm (10 inches) within the clear width of the stair.

Exceptions:

1. Spiral stairways in accordance with Clause 11.11.10.

2. Stairways connecting stepped aisles to cross aisles or concourses shall be permitted to use the riser/tread dimension in Clause 11.29.14.2.

3. In Group R-3 occupancies; within dwelling units in Group R-2 occupancies; and in Group U occupancies that are accessory to a Group R-3 occupancy or accessory to individual dwelling units in Group R-2 occupancies; the maximum riser height shall be 197 mm (73/4 inches); the minimum tread depth shall be 254 mm (10 inches); the minimum winder tread depth at the walkline shall be 254 mm (10 inches); and the minimum winder tread depth shall be 152 mm (6 inches). A nosing projection not less than 19.1 mm (3/4 inch) but not more than 32 mm (11/4 inches) shall be provided on stairways with solid risers where the tread depth is less than 279 mm (11 inches).

4. See this Code for the replacement of existing stairways.

5. In Group I-3 facilities, stairways providing access to guard towers, observation stations and control rooms, not more than 23 m2 (250 square feet) in area, shall be permitted to have a maximum riser height of 203 mm (8 inches) and a minimum tread depth of 229 mm (9 inches).

11.11.5.3 Winder treads.

Winder treads are not permitted in means of escape stairways except within a dwelling unit.

Exceptions:

1. Curved stairways in accordance with Clause 11.11.9.

2. Spiral stairways in accordance with Clause 11.11.10.

11.11.5.4 Dimensional uniformity.

Stair treads and risers shall be of uniform size and shape. The tolerance between the largest and smallest riser height or between the largest and smallest tread depth shall not exceed 9.5 mm (3/8 inch) in any flight of stairs. The greatest winder tread depth at the walkline within any flight of stairs shall not exceed the smallest by more than 9.5 mm (3/8 inch).
Exceptions:

1. Stairways connecting stepped aisles to cross aisles or concourses shall be permitted to comply with the dimensional nonuniformity in Clause 11.29.14.2.

2. Consistently shaped winders, complying with Clause 11.11.5, differing from rectangular treads in the same flight of stairs.

3. Nonuniform riser dimension complying with Clause 11.11.5.4.1.

11.11.5.4.1 Nonuniform height risers.

Where the bottom or top riser adjoins a sloping public way, walkway or driveway having an established grade and serving as a landing, the bottom or top riser is permitted to be reduced along the slope to less than 102 mm (4 inches) in height, with the variation in height of the bottom or top riser not to exceed one unit vertical in 12 units horizontal (8-percent slope) of stair width. The nosings or leading edges of treads at such nonuniform height risers shall have a distinctive marking stripe, different from any other nosing marking provided on the stair flight. The distinctive marking stripe shall be visible in descent of the stair and shall have a slip-resistant surface. Marking stripes shall have a width of not less than 25 mm (1 inch) but not more than 51 mm (2 inches).

11.11.5.5 Nosing and riser profile.

Nosings shall have a curvature or bevel of not less than 1.6 mm (1/16 inch) but not more than 14.3 mm (9/16 inch) from the foremost projection of the tread. Risers shall be solid and vertical or sloped under the tread above from the underside of the nosing above at an angle not more than 30 degrees (0.52 rad) from the vertical.

11.11.5.5.1 Nosing projection size.

The leading edge (nosings) of treads shall project not more than 32 mm (11/4 inches) beyond the tread below.

11.11.5.5.2 Nosing projection uniformity.

Nosings projections of the leading edges shall be of uniform size, including the projections of the nosing’s leading edge of the floor at the top of a flight.

11.11.5.5.3 Solid risers.

Risers shall be solid.

Exceptions:

1. Solid risers are not required for stairways that are not required to comply with Clause 11.9.3, provided that the opening between treads does not permit the passage of a sphere with a diameter of 102 mm (4 inches).

2. Solid risers are not required for occupancies in Group I-3 or in Group F, H and S occupancies other than areas accessible to the public. The size of the opening in the riser is not restricted.

3. Solid risers are not required for spiral stairways constructed in accordance with Clause 11.11.10.

11.11.6 Stairway landings.

There shall be a floor or landing at the top and bottom of each stairway. The width of landings, measured perpendicularly to the direction of travel, shall be not less than the width of stairways served. Every landing shall have a minimum depth, measured parallel to the direction of travel, equal to the width of the stairway or 1219 mm (48 inches), whichever is less. Doors opening onto a landing shall not reduce the landing to less than one-half the required width. When fully open, the door shall not project more than 178 mm (7 inches) into a landing. Where wheelchair spaces are required on the stairway landing in accordance with Clause 11.9.6.3, the wheelchair space shall not be located in the required width of the landing and doors shall not swing over the wheelchair spaces.

Exception: Where stairways connect stepped aisles to cross aisles or concourses, stairway landings are not required at the transition between stairways and stepped aisles constructed in accordance with Clause 11.29.
11.11.7 Stairway construction.

Stairways shall be built of materials consistent with the types permitted for the type of construction of the building, except that wood handrails shall be permitted for all types of construction.

11.11.7.1 Stairway walking surface.

The walking surface of treads and landings of a stairway shall not be sloped steeper than one unit vertical in 48 units horizontal (2-percent slope) in any direction. Stairway treads and landings shall have a solid surface. Finish floor surfaces shall be securely attached.

Exceptions:

1. Openings in stair walking surfaces shall be a size that does not permit the passage of 12.7 mm (1/2-inch-diameter) sphere. Elongated openings shall be placed so that the long dimension is perpendicular to the direction of travel.

2. In Group F, H and S occupancies, other than areas of parking structures accessible to the public, openings in treads and landings shall not be prohibited provided that a sphere with a diameter of 29 mm (11/8 inches) cannot pass through the opening.

11.11.7.2 Outdoor conditions.

Outdoor stairways and outdoor approaches to stairways shall be designed so that water will not accumulate on walking surfaces.

11.11.7.3 Enclosures under interior stairways.

The walls and soffits within enclosed usable spaces under enclosed and unenclosed stairways shall be protected by 1-hour fire-resistance-rated construction or the fire-resistance rating of the stairway enclosure, whichever is greater. Access to the enclosed space shall not be directly from within the stairway enclosure.

Exception: Spaces under stairways serving and contained within a single residential dwelling unit in Group R-2 or R-3 shall be permitted to be protected on the enclosed side with 12.7 mm (1/2-inch) gypsum board.

11.11.7.4 Enclosures under exterior stairways.

There shall not be enclosed usable space under exterior exit stairways unless the space is completely enclosed in 1-hour fire-resistance-rated construction. The open space under exterior stairways shall not be used for any purpose.

11.11.8 Vertical rise.

A flight of stairs shall not have a vertical rise greater than 3658 mm (12 feet) between floor levels or landings.

Exception: Spiral stairways used as a means of escape from technical production areas.

11.11.9 Curved stairways.

Curved stairways with winder treads shall have treads and risers in accordance with Clause 11.11.5 and the smallest radius shall be not less than twice the minimum width or required capacity of the stairway.

Exception: The radius restriction shall not apply to curved stairways in Group R-3 and within individual dwelling units in Group R-2.

11.11.10 Spiral stairways.

Spiral stairways are permitted to be used as a component in the means of Escape only within dwelling units or from a space not more than 23 m² (250 square feet) in area and serving not more than five occupants, or from technical production areas in accordance with Clause 4.10.5.

A spiral stairway shall have a 171 mm minimum clear tread depth at a point 305 mm (12 inches) from the narrow edge. The risers shall be sufficient to provide a headroom of 1981 mm (78 inches) minimum, but riser height shall not be more than 241 mm (9 1/2 inches). The minimum stairway clear width at and below the handrail shall be 660 mm (26 inches).
11.11.11 Handrails.

Flights of stairways shall have handrails on each side and shall comply with Clause 11.14. Where glass is used to provide the handrail, the handrail shall comply with Clause 25.7.

Exceptions:

1. Flights of stairways within dwelling units and flights of spiral stairways are permitted to have a handrail on one side only.

2. Decks, patios and walkways that have a single change in elevation where the landing depth on each side of the change of elevation is greater than what is required for a landing do not require handrails.

3. In Group R-3 occupancies, a change in elevation consisting of a single riser at an entrance or Escape door does not require handrails.

4. Changes in room elevations of three or fewer risers within dwelling units and sleeping units in Group R-2 and R-3 do not require handrails.

11.11.12 Stairway to roof.

In buildings four or more stories above grade plane, one stairway shall extend to the roof surface unless the roof has a slope steeper than four units vertical in 12 units horizontal (33-percent slope).

Exception: Other than where required by Clause 11.11.12.1, in buildings without an occupied roof access to the roof from the top storey shall be permitted to be by an alternating tread device, a ships ladder or a permanent ladder.

11.11.12.1 Stairway to elevator equipment.

Roofs and penthouses containing elevator equipment that must be accessed for maintenance are required to be accessed by a stairway.

11.11.12.2 Roof access.

Where a stairway is provided to a roof, access to the roof shall be provided through a penthouse complying with Clause 16.10.2.

Exception: In buildings without an occupied roof, access to the roof shall be permitted to be a roof hatch or trap door not less than 1.5 m² (16 square feet) in area and having a minimum dimension of 610 mm (2 feet).

11.11.13 Guards.

 Guards shall be provided along stairways and landings where required by Clause 11.15 and shall be constructed in accordance with Clause 11.15. Where the roof hatch opening providing the required access is located within 10 feet (3049 mm) of the roof edge, such roof access or roof edge shall be protected by guards installed in accordance with Clause 11.15.

11.11.14 Alternating tread devices.

Alternating tread devices are limited to an element of a means of Escape in buildings of Groups F, H and S from a mezzanine not more than 23 m² (250 square feet) in area and that serves not more than five occupants; in buildings of Group I-3 from a guard tower, observation station or control room not more than 23 m² (250 square feet) in area and for access to unoccupied roofs. Alternating tread devices used as a means of Escape shall not have a rise greater than 6096 mm (20 feet) between floor levels or landings.

11.11.14.1 Handrails of alternating tread devices.

Handrails shall be provided on both sides of alternating tread devices and shall comply with Clause 11.14.

11.11.14.2 Treads of alternating tread devices.

Alternating tread devices shall have a minimum tread depth of 127 mm (5 inches), a minimum projected tread depth of 216 mm (8½ inches), a minimum tread width of 178 mm (7 inches) and a maximum riser height of 241 mm (9½ inches). The tread depth shall be measured horizontally between the vertical planes of the foremost projections of adjacent treads. The riser height shall be measured vertically between the leading edges of adjacent treads. The riser height and tread depth provided shall result in an angle of ascent from the horizontal of between 50 and 70 degrees (0.87 and 1.22 rad). The initial tread of the device shall begin
at the same elevation as the platform, landing or floor surface.

**Exception:** Alternating tread devices used as an element of a means of Escape in buildings from a mezzanine area not more than 23 $m^2$ (250 square feet) in area that serves not more than five occupants shall have a minimum tread depth of 76 mm (3 inches) with a minimum projected tread depth of 267 mm (101/2 inches). The rise to the next alternating tread surface shall not exceed 203 mm (8 inches).

**11.11.15 Ships ladders.**

Ships ladders are permitted to be used in Group I-3 as a component of a means of escape to and from control rooms or elevated facility observation stations not more than 23 $m^2$ (250 square feet) with not more than three occupants and for access to unoccupied roofs. The minimum clear width at and below the handrails shall be 508 mm (20 inches).

**11.11.15.1 Handrails of ships ladders.**

Handrails shall be provided on both sides of ships ladders.

**11.11.15.2 Treads of ships ladders.**

Ships ladders shall have a minimum tread depth of 127 mm (5 inches). The tread shall be projected such that the total of the tread depth plus the nosing projection is not less than 216 mm (81/2 inches). The maximum riser height shall be 241 mm (91/2 inches).

**11.11.16 Ladders.**

Permanent ladders shall not serve as a part of the means of Escape from occupied spaces within a building. Permanent ladders shall be constructed in accordance with this Code. Permanent ladders shall be permitted to provide access to the following areas:

1. Spaces frequented only by personnel for maintenance, repair or monitoring of equipment.
2. Nonoccupiable spaces accessed only by catwalks, crawl spaces, freight elevators or very narrow passageways.
3. Raised areas used primarily for purposes of security, life safety or fire safety including, but not limited to, observation galleries, prison guard towers, fire towers or lifeguard stands.
4. Elevated levels in Group U not open to the general public.
5. Nonoccupied roofs that are not required to have stairway access in accordance with Clause 11.11.12.1.
6. Where permitted to access equipment and appliances in accordance with this Code.

**11.12 RAMPS**

**11.12.1 Scope.**

The provisions of this Clause shall apply to ramps used as a component of a means of Escape.

**Exceptions:**

1. Ramped aisles within assembly rooms or spaces shall comply with the provisions in Clause 11.29.
2. Curb ramps shall comply with ICC A117.1.
3. Vehicle ramps in parking garages for pedestrian exit access shall not be required to comply with Clauses 11.12.3 through 11.12.10 where they are not an accessible route serving accessible parking spaces, other required accessible elements or part of an accessible means of escape.

**11.12.2 Slope.**

Ramps used as part of a means of Escape shall have a running slope not steeper than one unit vertical in 12 units horizontal (8-percent slope). The slope of other pedestrian ramps shall not be steeper than one unit vertical in eight units horizontal (12.5-percent slope).

**11.12.3 Cross slope.**

The slope measured perpendicular to the direction of travel of a ramp shall not be steeper than one unit vertical in 48 units horizontal (2-percent slope).
11.12.4 Vertical rise.
The rise for any ramp run shall be 762 mm (30 inches) maximum.

11.12.5 Minimum dimensions.
The minimum dimensions of means of escape ramps shall comply with Clauses 11.12.5.1 through 11.12.5.3.

11.12.5.1 Width and capacity.
The minimum width and required capacity of a means of escape ramp shall be not less than that required for corridors by Clause 11.20.2. The clear width of a ramp between handrails, if provided, or other permissible projections shall be 914 mm (36 inches) minimum.

11.12.5.2 Headroom.
The minimum headroom in all parts of the means of escape ramp shall be not less than 2032 mm (80 inches) above the finished floor of the ramp run and any intermediate landings. The minimum clearance shall be maintained for the full width of the ramp and landing.

11.12.5.3 Restrictions.
Means of escape ramps shall not reduce in width in the direction of escape travel. Projections into the required ramp and landing width are prohibited. Doors opening onto a landing shall not reduce the clear width to less than 1067 mm (42 inches).

11.12.6 Landings.
Ramps shall have landings at the bottom and top of each ramp, points of turning, entrance, exits and at doors. Landings shall comply with Clauses 11.12.6.1 through 11.12.6.5.

11.12.6.1 Slope.
Landings shall have a slope not steeper than one unit vertical in 48 units horizontal (2-percent slope) in any direction. Changes in level are not permitted.

11.12.6.2 Width.
The landing width shall be not less than the width of the widest ramp run adjoining the landing.

11.12.6.3 Length.
The landing length shall be 1525 mm (60 inches) minimum.

Exceptions:
1. In Group R-2 and R-3 individual dwelling and sleeping units that are not required to be Accessible units, Type A units or Type B units in accordance with Clause 11.07, landings are permitted to be 914 mm (36 inches) minimum.

2. Where the ramp is not a part of an accessible route, the length of the landing shall not be required to be more than 1220 mm (48 inches) in the direction of travel.

11.12.6.4 Change in direction.
Where changes in direction of travel occur at landings provided between ramp runs, the landing shall be 1524 mm by 1524 mm (60 inches by 60 inches) minimum.

Exception: In Group R-2 and R-3 individual dwelling or sleeping units that are not required to be Accessible units, Type A units or Type B units in accordance with Clause 12.07, landings are permitted to be 914 mm by 914 mm (36 inches by 36 inches) minimum.

11.12.6.5 Doorways.
Where doorways are located adjacent to a ramp landing, maneuvering clearances required by ICC A117.1 are permitted to overlap the required landing area.

11.12.7 Ramp construction.
Ramps shall be built of materials consistent with the types permitted for the type of construction of the building, except that wood handrails shall be permitted for all types of construction.
11.12.7.1 Ramp surface.
The surface of ramps shall be of slip-resistant materials that are securely attached.

11.12.7.2 Outdoor conditions.
Outdoor ramps and outdoor approaches to ramps shall be designed so that water will not accumulate on walking surfaces.

11.12.8 Handrails.
Ramps with a rise greater than 152 mm (6 inches) shall have handrails on both sides. Handrails shall comply with Clause 11.14.

11.12.9 Guards.
Guards shall be provided where required by Clause 11.15 and shall be constructed in accordance with Clause 11.15.

11.12.10 Edge protection.
Edge protection complying with Clause 11.12.10.1 or 11.12.10.2 shall be provided on each side of ramp runs and at each side of ramp landings.

Exceptions:

1. Edge protection is not required on ramps that are not required to have handrails, provided they have flared sides that comply with the ICC A117.1 curb ramp provisions.

2. Edge protection is not required on the sides of ramp landings serving an adjoining ramp run or stairway.

3. Edge protection is not required on the sides of ramp landings having a vertical dropoff of not more than 12.7 mm (1/2 inch) within 254 mm (10 inches) horizontally of the required landing area.

11.12.10.1 Curb, rail, wall or barrier.
A curb, rail, wall or barrier shall be provided to serve as edge protection. A curb shall be not less than 102 mm (4 inches) in height. Barriers shall be constructed so that the barrier prevents the passage of a 102 mm (4-inch-diameter) sphere, where any portion of the sphere is within 102 mm (4 inches) of the floor or ground surface.

11.12.10.2 Extended floor or ground surface.
The floor or ground surface of the ramp run or landing shall extend 305 mm (12 inches) minimum beyond the inside face of a handrail complying with Clause 11.14.

11.13 EXIT SIGNS

11.13.1 Where required.
Exits and exit access doors shall be marked by an approved exit sign readily visible from any direction of escape travel. The path of escape travel to exits and within exits shall be marked by readily visible exit signs to clearly indicate the direction of escape travel in cases where the exit or the path of escape travel is not immediately visible to the occupants. Intervening means of escape doors within exits shall be marked by exit signs. Exit sign placement shall be such that any point in an exit access corridor or exit passageway is within 100 feet (30 480 mm) or the listed viewing distance of the sign, whichever is less, from the nearest visible exit sign.

Exceptions:

1. Exit signs are not required in rooms or areas that require only one exit or exit access.

2. Main exterior exit doors or gates that are obviously and clearly identifiable as exits need not have exit signs where approved by the building official.

3. Exit signs are not required in occupancies in Group U and individual sleeping units or dwelling units in Group R-1, R-2 or R-3.

4. Exit signs are not required in dayrooms, sleeping rooms or dormitories in occupancies in Group I-3.

5. In occupancies in Groups A-4 and A-5, exit signs are not required on the seating side of vomitories or openings into seating areas where exit signs are provided in the concourse that are readily apparent from the vomitories. Escape lighting is provided to identify each vomitory or opening within the seating area in an emergency.
11.13.2 Low-level exit signs in Group R-1.

Where exit signs are required in Group R-1 occupancies by Clause 11.13.1, additional low-level exit signs shall be provided in all areas serving guest rooms in Group R-1 occupancies and shall comply with Clause 11.13.5.

The bottom of the sign shall be not less than 254 mm (10 inches) nor more than 455 mm (18 inches) above the floor level. The sign shall be flush mounted to the door or wall. Where mounted on the wall, the edge of the sign shall be within 102 mm (4 inches) of the door frame on the latch side.

11.13.3 Illumination.

Exit signs shall be internally or externally illuminated.

Exception: Tactile signs required by Clause 11.13.4 need not be provided with illumination.

11.13.4 Raised character and braille exit signs.

A sign stating EXIT in visual characters, raised characters and braille and complying with ICC A117.1 shall be provided adjacent to each door to an area of refuge, providing direct access to a stairway, an exterior area for assisted rescue, an exit stairway or ramp, an exit passageway and the exit discharge.

11.13.5 Internally illuminated exit signs.

Electrically powered, self-luminous and photoluminescent exit signs shall be listed and labeled in accordance with this Code and shall be installed in accordance with the manufacturer’s instructions. Exit signs shall be illuminated at all times.

11.13.6 Externally illuminated exit signs.

Externally illuminated exit signs shall comply with Clauses 11.13.6.1 through 11.13.6.3.

11.13.6.1 Graphics.

Every exit sign and directional exit sign shall have plainly legible letters not less than 152 mm (6 inches) high with the principal strokes of the letters not less than 19.1 mm (3/4 inch) wide. The word “EXIT” shall have letters having a width not less than 51 mm (2 inches) wide, except the letter “I,” and the minimum spacing between letters shall be not less than 9.5 mm (3/8 inch). Signs larger than the minimum established in this Clause shall have letter widths, strokes and spacing in proportion to their height.

The word “EXIT” shall be in high contrast with the background and shall be clearly discernible when the means of exit sign illumination is or is not energized. If a chevron directional indicator is provided as part of the exit sign, the construction shall be such that the direction of the chevron directional indicator cannot be readily changed.

11.13.6.2 Exit sign illumination.

The face of an exit sign illuminated from an external source shall have an intensity of not less than 54 lux (5 footcandles).

11.13.6.3 Power source.

Exit signs shall be illuminated at all times. To ensure continued illumination for a duration of not less than 90 minutes in case of primary power loss, the sign illumination means shall be connected to an emergency power system provided from storage batteries, unit equipment or an on-site generator. The installation of the emergency power system shall be in accordance with this Code. Group I-2, Condition 2 exit sign illumination shall not be provided by unit equipment batteries only.

Exception: Approved exit sign illumination types that provide continuous illumination independent of external power sources for a duration of not less than 90 minutes, in case of primary power loss, are not required to be connected to an emergency electrical system.

11.14 HANDRAILS


11.14.2 Height.

Handrail height, measured above stair tread nosings, or finish surface of ramp slope, shall be uniform, not less than 864 mm (34 inches) and not more than 965 mm (38 inches). Handrail height of alternating tread devices and ships ladders, measured above tread nosings, shall be uniform, not less than 762 mm (30 inches) and not more than 864 mm (34 inches).

Exceptions:

1. Where handrail fittings or bendings are used to provide continuous transition between flights, the fittings or bendings shall be permitted to exceed the maximum height.

2. In Group R-3 occupancies; within dwelling units in Group R-2 occupancies; and in Group U occupancies that are associated with a Group R-3 occupancy or associated with individual dwelling units in Group R-2 occupancies; where handrail fittings or bendings are used to provide continuous transition between flights, transition at winder treads, transition from handrail to guard, or where used at the start of a flight, the handrail height at the fittings or bendings shall be permitted to exceed the maximum height.

3. Handrails on top of a guard where permitted along stepped aisles and ramped aisles in accordance with Clause 11.29.16.

11.14.3 Handrail graspalibility.

Required handrails shall comply with Clause 11.14.3.1 or shall provide equivalent graspalibility.

Exception: In Group R-3 occupancies; within dwelling units in Group R-2 occupancies; and in Group U occupancies that are accessory to a Group R-3 occupancy or accessory to individual dwelling units in Group R-2 occupancies; handrails shall be Type I in accordance with Clause 11.14.3.1, Type II in accordance with Clause 11.14.3.2 or shall provide equivalent graspalibility.
clearance dimension of 38 mm (11/2 inches) shall be permitted to be reduced by 3.2 mm (1/8 inch).

4. Where handrails are provided along walking surfaces with slopes not steeper than 1:20, the bottoms of the handrail gripping surfaces shall be permitted to be obstructed along their entire length where they are integral to crash rails or bumper guards.

5. Handrails serving stepped aisles or ramped aisles are permitted to be discontinuous in accordance with Clause 11.29.16.1.

11.14.5 Fittings.
Handrails shall not rotate within their fittings.

11.14.6 Handrail extensions.
Handrails shall return to a wall, guard or the walking surface or shall be continuous to the handrail of an adjacent flight of stairs or ramp run. Where handrails are not continuous between flights, the handrails shall extend horizontally not less than 305 mm (12 inches) beyond the top riser and continue to slope for the depth of one tread beyond the bottom riser. At ramps where handrails are not continuous between runs, the handrails shall extend horizontally above the landing 305 mm (12 inches) minimum beyond the top and bottom of ramp runs. The extensions of handrails shall be in the same direction of the flights of stairs at stairways and the ramp runs at ramps.

Exceptions:

1. Handrails within a dwelling unit that is not required to be accessible need extend only from the top riser to the bottom riser.

2. Handrails serving aisles in rooms or spaces used for assembly purposes are permitted to comply with the handrail extensions in accordance with Clause 11.29.16.

3. Handrails for alternating tread devices and ships ladders are permitted to terminate at a location vertically above the top and bottom risers. Handrails for alternating tread devices are not required to be continuous between flights or to extend beyond the top or bottom risers.

11.14.7 Clearance.
Clear space between a handrail and a wall or other surface shall be not less than 38 mm (11/2 inches). A handrail and a wall or other surface adjacent to the handrail shall be free of any sharp or abrasive elements.

11.14.8 Projections.
On ramps and on ramped aisles that are part of an accessible route, the clear width between handrails shall be 914 mm (36 inches) minimum. Projections into the required width of aisles, stairways and ramps at each side shall not exceed 114 mm (41/2 inches) at or below the handrail height. Projections into the required width shall not be limited above the minimum headroom height required in Clause 11.11.3. Projections due to intermediate handrails shall not constitute a reduction in the escape width. Where a pair of intermediate handrails are provided within the stairway width without a walking surface between the pair of intermediate handrails and the distance between the pair of intermediate handrails is greater than 152 mm (6 inches), the available Escape width shall be reduced by the distance between the closest edges of each such intermediate pair of handrails that is greater than 152 mm (6 inches).

Stairways shall have intermediate handrails located in such a manner that all portions of the stairway minimum width or required capacity are within 762 mm (30 inches) of a handrail. On monumental stairs, handrails shall be located along the most direct path of escape travel.

11.15 GUARDS

11.15.1 General.
Guards shall comply with the provisions of Clauses 11.15.2 through 11.15.7. Operable windows with sills located more than 1829 mm (72 inches) above finished grade or other surface below shall comply with Clause 11.15.8.

11.15.2 Where required.
Guards shall be located along open-sided walking surfaces, including mezzanines, equipment platforms, aisles, stairs, ramps and landings that are located more than 762 mm
(30 inches) measured vertically to the floor or grade below at any point within 914 mm (36 inches) horizontally to the edge of the open side. Guards shall be adequate in strength and attachment in accordance with this Code.

**Exception:** Guards are not required for the following locations:

1. On the loading side of loading docks or piers.
2. On the audience side of stages and raised platforms, including stairs leading up to the stage and raised platforms.
3. On raised stage and platform floor areas, such as runways, ramps and side stages used for entertainment or presentations.
4. At vertical openings in the performance area of stages and platforms.
5. At elevated walking surfaces appurtenant to stages and platforms for access to and utilization of special lighting or equipment.
6. Along vehicle service pits not accessible to the public.
7. In assembly seating areas at cross aisles in accordance with Clause 11.29.17.2.

11.15.2.1 Glazing.

Where glass is used to provide a guard or as a portion of the guard system, the guard shall comply with Clause 25.7. Where the glazing provided does not meet the strength and attachment requirements of this Code, complying guards shall be located along glazed sides of open-sided walking surfaces.

11.15.3 Height.

Required guards shall be not less than 1067 mm (42 inches) high, measured vertically as follows:

1. From the adjacent walking surfaces.
2. On stairways and stepped aisles, from the line connecting the leading edges of the tread nosings.
3. On ramps and ramped aisles, from the ramp surface at the guard.

**Exceptions:**

1. For occupancies in Group R-3 not more than three stories above grade in height and within individual dwelling units in occupancies in Group R-2 not more than three stories above grade in height with separate means of Escape, required guards shall be not less than 914 mm (36 inches) in height measured vertically above the adjacent walking surfaces.

2. For occupancies in Group R-3, and within individual dwelling units in occupancies in Group R-2, guards on the open sides of stairs shall have a height not less than 864 mm (34 inches) measured vertically from a line connecting the leading edges of the treads.

3. For occupancies in Group R-3, and within individual dwelling units in occupancies in Group R-2, where the top of the guard serves as a handrail on the open sides of stairs, the top of the guard shall be not less than 864 mm (34 inches) and not more than 965 mm (38 inches) measured vertically from a line connecting the leading edges of the treads.

4. The guard height in assembly seating areas shall comply with Clause 11.29.17 as applicable.

5. Along alternating tread devices and ships ladders, guards where the top rail serves as a handrail shall have height not less than 762 mm (30 inches) and not more than 864 mm (34 inches), measured vertically from the leading edge of the device tread nosing.

6. In Group F occupancies where exit access stairways serve fewer than three stories and such stairways are not open to the public, and where the top of the guard also serves as a handrail, the top of the guard shall be not less than 864 mm (34 inches) and not more than 965 mm (38 inches) measured vertically from a line connecting the leading edges of the treads.
11.15.4 Opening limitations.

Required guards shall not have openings that allow passage of a sphere 102 mm (4 inches) in diameter from the walking surface to the required guard height.

Exceptions:

1. From a height of 914 mm (36 inches) to 1067 mm (42 inches), guards shall not have openings that allow passage of a sphere 111 mm (43/8 inches) in diameter.
2. The triangular openings at the open sides of a stair, formed by the riser, tread and bottom rail shall not allow passage of a sphere 152 mm (6 inches) in diameter.
3. At elevated walking surfaces for access to and use of electrical, mechanical or plumbing systems or equipment, guards shall not have openings that allow passage of a sphere 533 mm (21 inches) in diameter.
4. In areas that are not open to the public within occupancies in Group I-3, F, H or S, and for alternating tread devices and ships ladders, guards shall not have openings that allow passage of a sphere 533 mm (21 inches) in diameter.
5. In assembly seating areas, guards required at the end of aisles in accordance with Clause 11.29.17.4 shall not have openings that allow passage of a sphere 102 mm (4 inches) in diameter up to a height of 660 mm (26 inches). From a height of 660 mm (26 inches) to 1067 mm (42 inches) above the adjacent walking surfaces, guards shall not have openings that allow passage of a sphere 203 mm (8 inches) in diameter.
6. Within individual dwelling units and sleeping units in Group R-2 and R-3 occupancies, guards on the open sides of stairs shall not have openings that allow passage of a sphere 111 mm (43/8 inches) in diameter.

11.15.5 Screen porches.

Porches and decks that are enclosed with insect screening shall be provided with guards where the walking surface is located more than 762 mm (30 inches) above the floor or grade below.

11.15.6 Mechanical equipment, systems and devices.

Guards shall be provided where various components that require service are located within 3048 mm (10 feet) of a roof edge or open side of a walking surface and such edge or open side is located more than 762 mm (30 inches) above the floor, roof or grade below. The guard shall extend not less than 762 mm (30 inches) beyond each end of such components. The guard shall be constructed so as to prevent the passage of a sphere 533 mm (21 inches) in diameter.

Exception: Guards are not required where personal fall arrest anchorage connector devices that comply with this Code are installed.

11.15.7 Roof access.

Guards shall be provided where the roof hatch opening is located within 3048 mm (10 feet) of a roof edge or open side of a walking surface and such edge or open side is located more than 762 mm (30 inches) above the floor, roof or grade below. The guard shall be constructed so as to prevent the passage of a sphere 533 mm (21 inches) in diameter.

Exception: Guards are not required where personal fall arrest anchorage connector devices that comply with this Code are installed.

11.15.8 Window openings.

Windows in Group R-2 and R-3 buildings including dwelling units, where the top of the sill of an operable window opening is located less than 36 inches above the finished floor and more than 1829 mm (72 inches) above the finished grade or other surface below on the exterior of the building, shall comply with one of the following:

1. Operable windows where the top of the sill of the opening is located more
than 22 860 mm (75 feet) above the finished grade or other surface below and that are provided with window fall prevention devices that comply with ASTM F2006.

2. Operable windows where the openings will not allow a 102 mm (4-inch-diameter) sphere to pass through the opening when the window is in its largest opened position.

3. Operable windows where the openings are provided with window fall prevention devices that comply with ASTM F2090.

4. Operable windows that are provided with window opening control devices that comply with Clause 11.15.8.1.

11.15.8.1 Window opening control devices.

Window opening control devices shall comply with ASTM F2090. The window opening control device, after operation to release the control device allowing the window to fully open, shall not reduce the minimum net clear opening area of the window unit to less than the area required by Clause 11.30.2.

11.16 EXIT ACCESS

11.16.1 General.

The exit access shall comply with the applicable provisions of Clauses 11.3 through 11.15. Exit access arrangement shall comply with Clauses 11.16 through 11.21.

11.16.2 Escape through intervening spaces.

Escape through intervening spaces shall comply with this Clause.

1. Exit access through an enclosed elevator lobby is permitted. Access to not less than one of the required exits shall be provided without travel through the enclosed elevator lobbies required by this Code. Where the path of exit access travel passes through an enclosed elevator lobby, the level of protection required for the enclosed elevator lobby is not required to be extended to the exit unless direct access to an exit is required by other Clauses of this Code.

2. Escape from a room or space shall not pass through adjoining or intervening rooms or areas, except where such adjoining rooms or areas and the area served are accessory to one or the other, are not a Group H occupancy and provide a discernible path of Escape travel to an exit.

1. Exception: Means of escape are not prohibited through adjoining or intervening rooms or spaces in a Group H, S or F occupancy where the adjoining or intervening rooms or spaces are the same or a lesser hazard occupancy group.

2. An exit access shall not pass through a room that can be locked to prevent escape.

3. Means of escape from dwelling units or sleeping areas shall not lead through other sleeping areas, toilet rooms or bathrooms.

4. Escape shall not pass through kitchens, storage rooms, closets or spaces used for similar purposes. Exceptions:

1. Means of escape are not prohibited through a kitchen area serving adjoining rooms constituting part of the same dwelling unit or sleeping unit.

2. Means of escape are not prohibited through stockrooms in Group M occupancies where all of the following are met:

2.1. The stock is of the same hazard classification as that found in the main retail area.

2.2. Not more than 50 percent of the exit access is through the stockroom.

2.3. The stockroom is not subject to locking from the escape side.

2.4. There is a demarcated, minimum 1118 mm-wide (44-inch) aisle defined by full- or partial-height fixed walls or similar construction that will
11.16.2.1 Multiple tenants.

Where more than one tenant occupies any one floor of a building or structure, each tenant space, dwelling unit and sleeping unit shall be provided with access to the required exits without passing through adjacent tenant spaces, dwelling units and sleeping units.

Exception: The means of escape from a smaller tenant space shall not be prohibited from passing through a larger adjoining tenant space where such rooms or spaces of the smaller tenant occupy less than 10 percent of the area of the larger tenant space through which they pass; are the same or similar occupancy group; a discernible path of escape travel to an exit is provided; and the means of Escape into the adjoining space is not subject to locking from the escape side. A required means of escape serving the larger tenant space shall not pass through the smaller tenant space or spaces.

11.17 EXIT ACCESS TRAVEL DISTANCE

11.17.1 General.

Travel distance within the exit access portion of the means of escape system shall be in accordance with this Clause.

11.17.2 Limitations.

Exit access travel distance shall not exceed the values given in Table 11.17.2.

**TABLE 11.17.2 EXIT ACCESS TRAVEL DISTANCE**

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>WITHOUT SPRINKLER SYSTEM (feet)</th>
<th>WITH SPRINKLER SYSTEM (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, E, F-1, M, R, S-1</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>I-1</td>
<td>Not Permitted</td>
<td>250</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>F-2, S-2, U</td>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td>H-1</td>
<td>Not Permitted</td>
<td>75</td>
</tr>
<tr>
<td>H-2</td>
<td>Not Permitted</td>
<td>100</td>
</tr>
<tr>
<td>H-3</td>
<td>Not Permitted</td>
<td>150</td>
</tr>
<tr>
<td>H-4</td>
<td>Not Permitted</td>
<td>175</td>
</tr>
<tr>
<td>H-5</td>
<td>Not Permitted</td>
<td>200</td>
</tr>
<tr>
<td>I-2, I-3</td>
<td>Not Permitted</td>
<td>200</td>
</tr>
<tr>
<td>I-4</td>
<td>150</td>
<td>200</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 foot = 304.8 mm.

(a) See the following Clauses for modifications to exit access travel distance requirements:
- Clause 4.2.8: For the distance limitation in malls.
- Clause 4.4.9: For the distance limitation through an atrium space.
- Clause 4.7.4: For the distance limitation in Group I-2.
- Clauses 4.8.6.1 and 408.8.1: For the distance limitations in Group I-3.
- Clause 4.11.3: For the distance limitation in special amusement buildings.
- Clause 4.12.6: For the distance limitations in aircraft manufacturing facilities.
- Clause 11.6.2.2.2: For the distance limitation in refrigeration machinery rooms.
- Clause 11.6.2.2.3: For the distance limitation in refrigerated rooms and spaces.
- Clause 11.6.3.3: For buildings with one exit.
- Clause 11.17.2.2: For increased distance limitation in Groups F-1 and S-1.
- Clause 11.29.7: For increased limitation in assembly seating.
- Clause 32.3.4: For temporary structures.
- Clause 32.4.9: For pedestrian walkways.

(b) Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2. See Clause 10.3 for occupancies where automatic sprinkler systems are permitted in accordance with Clause 10.3.3.1.2.

(c) Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

(d) Group H occupancies equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.5.1.

(e) Group R-3 and R-4 buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.2.8 for occupancies where automatic sprinkler systems are permitted in accordance with Clause 10.3.3.1.3.

11.17.2.1 Exterior Escape balcony increase.

Exit access travel distances specified in Table 11.17.2 shall be increased up to an additional 30 480 mm (100 feet) provided that the last portion of the exit access leading to the exit occurs on an exterior Escape balcony constructed in accordance with Clause 11.21. The length of such balcony shall be not less than the amount of the increase taken.

11.17.2.2 Groups F-1 and S-1 increase.

The maximum exit access travel distance shall be 122 m (400 feet) in Group F-1 or S-1 occupancies where all of the following conditions are met:
1. The portion of the building classified as Group F-1 or S-1 is limited to one storey in height.
2. The minimum height from the finished floor to the bottom of the ceiling or roof slab or deck is 7315 mm (24 feet).
3. The building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

11.17.3 Measurement.

Exit access travel distance shall be measured from the most remote point of each room, area or space along the natural and unobstructed path of horizontal and vertical escape travel to the entrance to an exit.

Exception: In open parking garages, exit access travel distance is permitted to be measured to the closest riser of an exit access stairway or the closest slope of an exit access ramp.

11.17.3.1 Exit access stairways and ramps.

Travel distance on exit access stairways or ramps shall be included in the exit access travel distance measurement. The measurement along stairways shall be made on a plane parallel and tangent to the stair tread nosings in the center of the stair and landings. The measurement along ramps shall be made on the walking surface in the center of the ramp and landings.

11.18 AISLES

11.18.1 General.

Aisles and aisle accessways serving as a portion of the exit access in the means of Escape system shall comply with the requirements of this Clause. Aisles or aisle accessways shall be provided from all occupied portions of the exit access that contain seats, tables, furnishings, displays and similar fixtures or equipment. The minimum width or required capacity of aisles shall be unobstructed.

Exception: Encroachments complying with Clause 11.5.7.

11.18.2 Aisles in assembly spaces.

Aisles and aisle accessways serving a room or space used for assembly purposes shall comply with Clause 11.29.

11.18.3 Aisles in Groups B and M.

In Group B and M occupancies, the minimum clear aisle width shall be determined by Clause 11.5.1 for the occupant load served, but shall be not less than that required for corridors by Clause 11.20.2.

Exception: Nonpublic aisles serving less than 50 people and not required to be accessible by Part 12 need not exceed 711 mm (28 inches) in width.

11.18.4 Aisle accessways in Group M.

An aisle accessway shall be provided on not less than one side of each element within the merchandise pad. The minimum clear width for an aisle accessway not required to be accessible shall be 762 mm (30 inches). The required clear width of the aisle accessway shall be measured perpendicular to the elements and merchandise within the merchandise pad. The 762 mm (30-inch) minimum clear width shall be maintained to provide a path to an adjacent aisle or aisle accessway. The common path of escape travel shall not exceed 9144 mm (30 feet) from any point in the merchandise pad.

Exception: For areas serving not more than 50 occupants, the common path of escape travel shall not exceed 22860 mm (75 feet).

11.18.5 Aisles in other than assembly spaces and Groups B and M.

In other than rooms or spaces used for assembly purposes and Group B and M occupancies, the minimum clear aisle capacity shall be determined by Clause 11.5.1 for the occupant load served, but the width shall be not less than that required for corridors by Clause 11.20.2.

Exception: Nonpublic aisles serving less than 50 people and not required to be accessible by Part 12 need not exceed 711 mm (28 inches) in width.
11.19 EXIT ACCESS STAIRWAYS AND RAMPS

11.19.1 General.

Exit access stairways and ramps serving as an exit access component in a means of escape system shall comply with the requirements of this Clause. The number of stories connected by exit access stairways and ramps shall include basements, but not mezzanines.

11.19.2 All occupancies.

Exit access stairways and ramps that serve floor levels within a single storey are not required to be enclosed.

11.19.3 Occupancies other than Groups I-2 and I-3.

In other than Group I-2 and I-3 occupancies, floor openings containing exit access stairways or ramps that do not comply with one of the conditions listed in this Clause shall be enclosed with a shaft enclosure constructed in accordance with Clause 8.13.

11.19.4 Group I-2 and I-3 occupancies.

In Group I-2 and I-3 occupancies, floor openings between stories containing exit access stairways or ramps are required to be enclosed with a shaft enclosure constructed in accordance with Clause 8.13.

Exception: In Group I-3 occupancies, exit access stairways or ramps constructed in accordance with Clause 4.8 are not required to be enclosed.

11.20 CORRIDORS

11.20.1 Construction.

Corridors shall be fire-resistance rated in accordance with Table 11.20.1. The corridor walls required to be fire-resistance rated shall comply with Clause 8.8 for fire partitions.

Exceptions:

1. A fire-resistance rating is not required for corridors in an occupancy in Group E where each room that is used for instruction has not less than one door opening directly to the exterior and rooms for assembly purposes have not less than one-half of the required means of escape doors opening directly to the exterior. Exterior doors specified in this exception are required to be at ground level.

2. A fire-resistance rating is not required for corridors contained within a dwelling unit or sleeping unit in an occupancy in Groups I-1 and R.

3. A fire-resistance rating is not required for corridors in open parking garages.
4. A fire-resistance rating is not required for corridors in an occupancy in Group B that is a space requiring only a single means of Escape complying with Clause 11.6.2.

5. Corridors adjacent to the exterior walls of buildings shall be permitted to have unprotected openings on unrated exterior walls where unrated walls are permitted by Table 7.2 and unprotected openings are permitted by Table 8.5.8.

### TABLE 11.20.1 CORRIDOR FIRE-RESISTANCE RATING

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>OCCUPANT LOAD SERVED BY CORRIDOR</th>
<th>REQUIRED FIRE-RESISTANCE RATING (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without sprinkler system</td>
</tr>
<tr>
<td>H-1, H-2, H-3</td>
<td>All</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>H-4, H-5</td>
<td>Greater than 30</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>A, B, E, F, M, S, U</td>
<td>Greater than 30</td>
<td>1</td>
</tr>
<tr>
<td>R</td>
<td>Greater than 10</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>I-2(^a)</td>
<td>All</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>I-1, I-3</td>
<td>All</td>
<td>Not Permitted</td>
</tr>
<tr>
<td>I-4</td>
<td>All</td>
<td>1</td>
</tr>
</tbody>
</table>

**Note:**

a. For requirements for occupancies in Group I-2, see Clauses 4.7.2 and 4.7.3.

b. For a reduction in the fire-resistance rating for occupancies in Group I-3, see Clause 4.8.8.

c. Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2 where allowed.

d. Group R-3 and R-4 buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.3. See Clause 10.3.2.8 for occupancies where automatic sprinkler systems are permitted in accordance with Clause 10.3.3.1.3.

#### 11.20.1.1 Hoistway opening protection.

Elevator hoistway openings shall be protected in accordance with this Code.

#### 11.20.2 Width and capacity.

The required capacity of corridors shall be determined as specified in Clause 11.5.1, but the minimum width shall be not less than that specified in Table 11.20.2.

**Exception:** In Group I-2 occupancies, corridors are not required to have a clear width of 96 inches (2438 mm) in areas where there will not be stretcher or bed movement for access to care or as part of the defend-in-place strategy.

### TABLE 11.20.2 MINIMUM CORRIDOR WIDTH

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>MINIMUM WIDTH (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any facility not listed in this table</td>
<td>44</td>
</tr>
<tr>
<td>Access to and utilization of mechanical, plumbing or electrical systems or equipment</td>
<td>24</td>
</tr>
</tbody>
</table>
11.20.3 Obstruction.

The minimum width or required capacity of corridors shall be unobstructed.

Exception: Encroachments complying with Clause 11.5.7.

11.20.4 Dead ends.

Where more than one exit or exit access doorway is required, the exit access shall be arranged such that dead-end corridors do not exceed 6096 mm (20 feet) in length.

Exceptions:

1. In in Group I-3, Condition 2, 3 or 4, occupancies, the dead end in a corridor shall not exceed 15 240 mm (50 feet).

2. In occupancies in Groups B, E, F, I-1, M, R-1, R-2, S and U, where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the length of the dead-end corridors shall not exceed 15 240 mm (50 feet).

3. A dead-end corridor shall not be limited in length where the length of the dead-end corridor is less than 2.5 times the least width of the dead-end corridor.

11.20.5 Air movement in corridors.

Corridors shall not serve as supply, return, exhaust, relief or ventilation air ducts.

Exceptions:

1. Use of a corridor as a source of makeup air for exhaust systems in rooms that open directly onto such corridors, including toilet rooms, bathrooms, dressing rooms, smoking lounges and janitor closets, shall be permitted, provided that each such corridor is directly supplied with outdoor air at a rate greater than the rate of makeup air taken from the corridor.

2. Where located within a dwelling unit, the use of corridors for conveying return air shall not be prohibited.

3. Where located within tenant spaces of 93 m² (1,000 square feet) or less in area, utilization of corridors for conveying return air is permitted.

4. Incidental air movement from pressurized rooms within health care facilities, provided that the corridor is not the primary source of supply or return to the room.

11.20.5.1 Corridor ceiling.

Use of the space between the corridor ceiling and the floor or roof structure above as a return air plenum is permitted for one or more of the following conditions:

1. The corridor is not required to be of fire-resistance-rated construction.

2. The corridor is separated from the plenum by fire-resistance-rated construction.

3. The air-handling system serving the corridor is shut down upon activation of the air-handling unit smoke detectors required by this Code.

4. The air-handling system serving the corridor is shut down upon detection of sprinkler water flow where the building is equipped throughout with an automatic sprinkler system.

5. The space between the corridor ceiling and the floor or roof structure above the corridor is used as a component of an approved engineered smoke control system.

11.20.6 Corridor continuity.

Fire-resistance-rated corridors shall be continuous from the point of entry to an exit, and shall not be interrupted by intervening
rooms. Where the path of escape travel within a fire-resistance-rated corridor to the exit includes travel along unenclosed exit access stairways or ramps, the fire-resistance rating shall be continuous for the length of the stairway or ramp and for the length of the connecting corridor on the adjacent floor leading to the exit.

Exceptions:

1. Foyers, lobbies or reception rooms constructed as required for corridors shall not be construed as intervening rooms.

2. Enclosed elevator lobbies as permitted by Item 1 of Clause 11.16.2 shall not be construed as intervening rooms.

11.21 ESCAPE BALCONIES

11.21.1 General.

Balconies used for escape purposes shall conform to the same requirements as corridors for minimum width, required capacity, headroom, dead ends and projections.

11.21.2 Wall separation.

Exterior escape balconies shall be separated from the interior of the building by walls and opening protectives as required for corridors.

Exception: Separation is not required where the exterior escape balcony is served by not less than two stairways and a dead-end travel condition does not require travel past an unprotected opening to reach a stairway.

11.21.3 Openness.

The long side of an escape balcony shall be not less than 50 percent open, and the open area above the guards shall be so distributed as to minimize the accumulation of smoke or toxic gases.

11.21.4 Location.

Exterior Escape balconies shall have a minimum fire separation distance of 3048 mm (10 feet) measured at right angles from the exterior edge of the escape balcony to the following:

1. Adjacent plot lines.
2. Other portions of the building.
3. Other buildings on the same plot unless the adjacent building exterior walls and openings are protected in accordance with Clause 8.5 based on fire separation distance.

For the purposes of this Clause, other portions of the building shall be treated as separate buildings.

11.22 EXITS

11.22.1 General.

Exits shall comply with Clauses 11.22 through 11.27 and the applicable requirements of Clauses 11.3 through 11.15. An exit shall not be used for any purpose that interferes with its function as a means of escape. Once a given level of exit protection is achieved, such level of protection shall not be reduced until arrival at the exit discharge. Exits shall be continuous from the point of entry into the exit to the exit discharge.

11.22.2 Exterior exit doors.

Buildings or structures used for human occupancy shall have not less than one exterior door that meets the requirements of Clause 11.10.1.1.

11.22.2.1 Detailed requirements.

Exterior exit doors shall comply with the applicable requirements of Clause 11.10.1.1.

11.22.2.2 Arrangement.

Exterior exit doors shall lead directly to the exit discharge or the public way.

11.23 INTERIOR EXIT STAIRWAYS AND RAMPS

11.23.1 General.

Interior exit stairways and ramps serving as an exit component in a means of escape system shall comply with the requirements of this Clause. Interior exit stairways and ramps shall
be enclosed and lead directly to the exterior of the building or shall be extended to the exterior of the building with an exit passageway conforming to the requirements of Clause 11.24, except as permitted in Clause 11.28.1. An interior exit stairway or ramp shall not be used for any purpose other than as a means of Escape and a circulation path.

11.23.2 Construction.

Enclosures for interior exit stairways and ramps shall be constructed as fire barriers in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both. Interior exit stairway and ramp enclosures shall have a fire-resistance rating of not less than 2 hours where connecting four stories or more and not less than 1 hour where connecting less than four stories. The number of stories connected by the interior exit stairways or ramps shall include any basements, but not any mezzanines. Interior exit stairways and ramps shall have a fire-resistance rating not less than the floor assembly penetrated, but need not exceed 2 hours.

Exceptions:

1. Interior exit stairways and ramps in Group I-3 occupancies in accordance with the provisions of Clause 4.8.3.8.
2. Interior exit stairways within an atrium enclosed in accordance with Clause 4.4.6.

11.23.3 Termination.

Interior exit stairways and ramps shall terminate at an exit discharge or a public way.

Exception: A combination of interior exit stairways, interior exit ramps and exit passageways, constructed in accordance with Clauses 11.23.2, 11.23.3.1 and 11.24, respectively, and forming a continuous protected enclosure, shall be permitted to extend an interior exit stairway or ramp to the exit discharge or a public way.

11.23.3.1 Extension.

Where interior exit stairways and ramps are extended to an exit discharge or a public way by an exit passageway, the interior exit stairway and ramp shall be separated from the exit passageway by a fire barrier constructed in accordance with Clause 8.7 or a horizontal assembly constructed in accordance with Clause 8.11, or both. The fire-resistance rating shall be not less than that required for the interior exit stairway and ramp. A fire door assembly complying with Clause 8.16 shall be installed in the fire barrier to provide a means of escape from the interior exit stairway and ramp to the exit passageway. Openings in the fire barrier other than the fire door assembly are prohibited. Penetrations of the fire barrier are prohibited.

Exceptions:

1. Penetrations of the fire barrier in accordance with Clause 11.23.5 shall be permitted.
2. Separation between an interior exit stairway or ramp and the exit passageway extension shall not be required where there are no openings into the exit passageway extension.
3. Separation between an interior exit stairway or ramp and the exit passageway extension shall not be required where the interior exit stairway and the exit passageway extension are pressurized in accordance with Clause 10.9.20.5.

11.23.4 Openings.

Interior exit stairway and ramp opening protectives shall be in accordance with the requirements of Clause 8.16.

Openings in interior exit stairways and ramps other than unprotected exterior openings shall be limited to those required for exit access to the enclosure from normally occupied spaces and for escape from the enclosure.

Elevators shall not open into interior exit stairways and ramps.

11.23.5 Penetrations.

Penetrations into or through interior exit stairways and ramps are prohibited except for the following:

1. Equipment and ductwork necessary for independent ventilation or pressurization.
2. Fire protection systems.
4. Two-way communication systems.

5. Electrical raceway for fire department communication systems.

6. Electrical raceway serving the interior exit stairway and ramp and terminating at a steel box not exceeding 0.010 m² (16 square inches).

Such penetrations shall be protected in accordance with Clause 8.14. There shall not be penetrations or communication openings, whether protected or not, between adjacent interior exit stairways and ramps.

Exception: Membrane penetrations shall be permitted on the outside of the interior exit stairway and ramp. Such penetrations shall be protected in accordance with Clause 8.14.4.2.

11.23.6 Ventilation.

Equipment and ductwork for interior exit stairway and ramp ventilation as permitted by Clause 11.23.5 shall comply with one of the following items:

1. Such equipment and ductwork shall be located exterior to the building and shall be directly connected to the interior exit stairway and ramp by ductwork enclosed in construction as required for shafts.

2. Where such equipment and ductwork is located within the interior exit stairway and ramp, the intake air shall be taken directly from the outdoors and the exhaust air shall be discharged directly to the outdoors, or such air shall be conveyed through ducts enclosed in construction as required for shafts.

3. Where located within the building, such equipment and ductwork shall be separated from the remainder of the building, including other mechanical equipment, with construction as required for shafts.

In each case, openings into the fire-resistance-rated construction shall be limited to those needed for maintenance and operation and shall be protected by opening protectives in accordance with Clause 8.16 for shaft enclosures.

The interior exit stairway and ramp ventilation systems shall be independent of other building ventilation systems.

11.23.7 Interior exit stairway and ramp exterior walls.

Exterior walls of the interior exit stairway or ramp shall comply with the requirements of Clause 8.5 for exterior walls. Where nonrated walls or unprotected openings enclose the exterior of the stairway or ramps and the walls or openings are exposed by other parts of the building at an angle of less than 180 degrees (3.14 rad), the building exterior walls within 3048 mm (10 feet) horizontally of a nonrated wall or unprotected opening shall have a fire-resistance rating of not less than 1 hour. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour. This construction shall extend vertically from the ground to a point 3048 mm (10 feet) above the topmost landing of the stairway or ramp, or to the roof line, whichever is lower.

11.23.8 Discharge identification.

An interior exit stairway and ramp shall not continue below its level of exit discharge unless an approved barrier is provided at the level of exit discharge to prevent persons from unintentionally continuing into levels below. Directional exit signs shall be provided as specified in Clause 11.13.

11.23.9 Stairway identification signs.

A sign shall be provided at each floor landing in an interior exit stairway and ramp connecting more than three stories designating the floor level, the terminus of the top and bottom of the interior exit stairway and ramp and the identification of the stairway or ramp. The signage shall state the storey of and direction to the exit discharge, and the availability of roof access from the interior exit stairway and ramp for the fire department. The sign shall be located 1524 mm (5 feet) above the floor landing in a position that is readily visible when the doors are in the open and closed positions. In addition to the stairway identification sign, a floor-level sign in visual characters, raised characters and braille complying with this Code shall be located at each floor-level landing adjacent to the door leading from the interior
exit stairway and ramp into the corridor to identify the floor level.

11.23.9.1 Signage requirements.

Stairway identification signs shall comply with all of the following requirements:

1. The signs shall be a minimum size of 457 mm (18 inches) by 305 mm (12 inches).

2. The letters designating the identification of the interior exit stairway and ramp shall be not less than 38 mm (1 1/2 inches) in height.

3. The number designating the floor level shall be not less than 5 inches (127 mm) in height and located in the center of the sign.

4. Other lettering and numbers shall be not less than 25 mm (1 inch) in height.

5. Characters and their background shall have a nonglare finish. Characters shall contrast with their background, with either light characters on a dark background or dark characters on a light background.

6. Where signs required by Clause 11.23.9 are installed in the interior exit stairways and ramps of buildings subject to Clause 11.25, the signs shall be made of the same materials as required by Clause 11.25.4.

11.23.10 Elevator lobby identification signs.

At landings in interior exit stairways where two or more doors lead to the floor level, any door with direct access to an enclosed elevator lobby shall be identified by signage located on the door or directly adjacent to the door stating “Elevator Lobby.” Signage shall be in accordance with Clause 11.23.9.1, Items 4, 5 and 6.

11.23.11 Smokeproof enclosures.

Where required by Clause 4.3.5.4, 4.5.7.2 or 4.12.2.2.1, interior exit stairways and ramps shall be smokeproof enclosures in accordance with Clause 10.9.20.

1023.11.1 Termination and extension.

A smokeproof enclosure shall terminate at an exit discharge or a public way. The smokeproof enclosure shall be permitted to be extended by an exit passageway in accordance with Clause 11.23.3. The exit passageway shall be without openings other than the fire door assembly required by Clause 11.23.3.1 and those necessary for Escape from the exit passageway. The exit passageway shall be separated from the remainder of the building by 2-hour fire barriers constructed in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

Exceptions:

1. Openings in the exit passageway serving a smokeproof enclosure are permitted where the exit passageway is protected and pressurized in the same manner as the smokeproof enclosure, and openings are protected as required for access from other floors.

2. The fire barrier separating the smokeproof enclosure from the exit passageway is not required, provided that the exit passageway is protected and pressurized in the same manner as the smokeproof enclosure.

3. A smokeproof enclosure shall be permitted to escape through areas on the level of exit discharge or vestibules as permitted by Clause 11.28.

11.23.11.2 Enclosure access.

Access to the stairway or ramp within a smokeproof enclosure shall be by way of a vestibule or an open exterior balcony.

Exception: Access is not required by way of a vestibule or exterior balcony for stairways and ramps using the pressurization alternative complying with Clause 10.9.20.5.

11.23.12 Standpipes.

Standpipes and Fire hydranthose connections shall be provided where required by Clauses 10.5.3 and 10.5.4.

11.24 EXIT PASSAGEWAYS
11.24.1 Exit passageways.
Exit passageways serving as an exit component in a means of escape system shall comply with the requirements of this Clause. An exit passageway shall not be used for any purpose other than as a means of escape and a circulation path.

1024.2 Width and capacity.
The required capacity of exit passageways shall be determined as specified in Clause 11.5.1 but the minimum width shall be not less than 1118 mm (44 inches), except that exit passageways serving an occupant load of less than 50 shall be not less than 914 mm (36 inches) in width. The minimum width or required capacity of exit passageways shall be unobstructed.

Exception: Encroachments complying with Clause 11.5.7.

11.24.3 Construction.
Exit passageway enclosures shall have walls, floors and ceilings of not less than a 1-hour fire-resistance rating, and not less than that required for any connecting interior exit stairway or ramp. Exit passageways shall be constructed as fire barriers in accordance with Clause 8.7 or horizontal assemblies constructed in accordance with Clause 8.11, or both.

11.24.4 Termination.
Exit passageways on the level of exit discharge shall terminate at an exit discharge. Exit passageways on other levels shall terminate at an exit.

11.24.5 Openings.
Exit passageway opening protectives shall be in accordance with the requirements of Clause 8.16.

Except as permitted in Clause 4.2.8.7, openings in exit passageways other than unprotected exterior openings shall be limited to those necessary for exit access to the exit passageway from normally occupied spaces and for escape from the exit passageway.

Where an interior exit stairway or ramp is extended to an exit discharge or a public way by an exit passageway, the exit passageway shall comply with Clause 11.23.3.1.

Elevators shall not open into an exit passageway.

11.24.6 Penetrations.
Penetrations into or through an exit passageway are prohibited except for the following:

1. Equipment and ductwork necessary for independent pressurization.
2. Fire protection systems.
4. Two-way communication systems.
5. Electrical raceway for fire department communication.
6. Electrical raceway serving the exit passageway and terminating at a steel box not exceeding 0.010 m² (16 square inches).

Such penetrations shall be protected in accordance with Clause 8.14. There shall not be penetrations or communicating openings, whether protected or not, between adjacent exit passageways.

Exception: Membrane penetrations shall be permitted on the outside of the exit passageway. Such penetrations shall be protected in accordance with Clause 8.14.4.2.

11.24.7 Ventilation.
Equipment and ductwork for exit passageway ventilation as permitted by Clause 11.24.6 shall comply with one of the following:

1. The equipment and ductwork shall be located exterior to the building and shall be directly connected to the exit passageway by ductwork enclosed in construction as required for shafts.
2. Where the equipment and ductwork is located within the exit passageway, the intake air shall be taken directly from the outdoors and the exhaust air shall be discharged directly to the outdoors, or the air shall be conveyed through ducts enclosed in construction as required for shafts.
3. Where located within the building, the equipment and ductwork shall be
separated from the remainder of the building, including other mechanical equipment, with construction as required for shafts.

In each case, openings into the fire-resistance-rated construction shall be limited to those needed for maintenance and operation and shall be protected by opening protectives in accordance with Clause 8.16 for shaft enclosures.

Exit passageway ventilation systems shall be independent of other building ventilation systems.

11.24.8 Fire Hydrant.

Fire Hydrant and Fire hydrant hose connections shall be provided where required by Clauses 10.5.3 and 10.5.4.

11.25 LUMINOUS ESCAPE PATH MARKINGS

11.25.1 General.

Approved luminous escape path markings delineating the exit path shall be provided in high-rise buildings of Group A, B, E, I-1, M or R-1 occupancies in accordance with this Clause.

Exception: Luminous escape path markings shall not be required on the level of exit discharge in lobbies that serve as part of the exit path in accordance with Clause 11.28.1, Exception 1.

11.25.2 Markings within exit components.

Escape path markings shall be provided in interior exit stairways, interior exit ramps and exit passageways, in accordance with Clauses 11.25.2.1 through 11.25.2.6.

11.25.2.1 Steps.

A solid and continuous stripe shall be applied to the horizontal leading edge of each step and shall extend for the full length of the step. Outlining stripes shall have a minimum horizontal width of 25 mm (1 inch) and a maximum width of 51 mm (2 inches). The leading edge of the stripe shall be placed not more than 12.7 mm (1/2 inch) from the leading edge of the step and the stripe shall not overlap the leading edge of the step by not more than 12.7 mm (1/2 inch) down the vertical face of the step.

Exception: The minimum width of 25 mm (1 inch) shall not apply to outlining stripes listed in accordance with this Code.

11.25.2.2 Landings.

The leading edge of landings shall be marked with a stripe consistent with the dimensional requirements for steps.

11.25.2.3 Handrails.

Handrails and handrail extensions shall be marked with a solid and continuous stripe having a minimum width of 25 mm (1 inch). The stripe shall be placed on the top surface of the handrail for the entire length of the handrail, including extensions and newel post caps. Where handrails or handrail extensions bend or turn corners, the stripe shall not have a gap of more than 102 mm (4 inches).

Exception: The minimum width of 25 mm (1 inch) shall not apply to outlining stripes listed in accordance with this Code.

11.25.2.4 Perimeter demarcation lines.

Stair landings and other floor areas within interior exit stairways, interior exit ramps and exit passageways, with the exception of the sides of steps, shall be provided with solid and continuous demarcation lines on the floor or on the walls or a combination of both. The stripes shall be 25 mm to 51 mm (1 to 2 inches) wide with interruptions not exceeding 102 mm (4 inches).

Exception: The minimum width of 25 mm (1 inch) shall not apply to outlining stripes listed in accordance with this Code.

1025.2.4.1 Floor-mounted demarcation lines.

Perimeter demarcation lines shall be placed within 102 mm (4 inches) of the wall and shall extend to within 51 mm (2 inches) of the markings on the leading edge of landings. The demarcation lines shall continue across the floor in front of all doors.

Exception: Demarcation lines shall not extend in front of exit discharge doors that lead out of
an exit and through which occupants must travel to complete the exit path.

11.25.2.4.2 Wall-mounted demarcation lines.

Perimeter demarcation lines shall be placed on the wall with the bottom edge of the stripe not more than 102 mm (4 inches) above the finished floor. At the top or bottom of the stairs, demarcation lines shall drop vertically to the floor within 51 mm (2 inches) of the step or landing edge. Demarcation lines on walls shall transition vertically to the floor and then extend across the floor where a line on the floor is the only practical method of outlining the path. Where the wall line is broken by a door, demarcation lines on walls shall continue across the face of the door or transition to the floor and extend across the floor in front of such door.

**Exception:** Demarcation lines shall not extend in front of exit discharge doors that lead out of an exit and through which occupants must travel to complete the exit path.

11.25.2.4.3 Transition.

Where a wall-mounted demarcation line transitions to a floor-mounted demarcation line, or vice versa, the wall-mounted demarcation line shall drop vertically to the floor to meet a complimentary extension of the floor-mounted demarcation line, thus forming a continuous marking.

11.25.2.5 Obstacles.

Obstacles at or below 1981 mm (6 feet 6 inches) in height and projecting more than 102 mm (4 inches) into the Escape path shall be outlined with markings not less than 25 mm (1 inch) in width comprised of a pattern of alternating equal bands, of luminous material and black, with the alternating bands not more than 51 mm (2 inches) thick and angled at 45 degrees (0.79 rad). Obstacles shall include, but are not limited to, standpipes, hose cabinets, wall projections and restricted height areas. However, such markings shall not conceal any required information or indicators including but not limited to instructions to occupants for the use of standpipes.

**Exception:** The minimum width of 25 mm (1 inch) shall not apply to markings listed in accordance with this Code.

11.25.2.6 Doors within the exit path.

Doors through which occupants must pass in order to complete the exit path shall be provided with markings complying with Clauses 11.25.2.6.1 through 11.25.2.6.3.

11.25.2.6.1 Emergency exit symbol.

The doors shall be identified by a low-location luminous emergency exit symbol complying with the Ghana Fire Code. The exit symbol shall be not less than 102 mm (4 inches) in height and shall be mounted on the door, centered horizontally, with the top of the symbol not higher than 457 mm (18 inches) above the finished floor.

11.25.2.6.2 Door hardware markings.

Door hardware shall be marked with not less than 406 mm² (16 square inches) of luminous material. This marking shall be located behind, immediately adjacent to, or on the door handle or escutcheon. Where a panic bar is installed, such material shall be not less than 25 mm (1 inch) wide for the entire length of the actuating bar or touchpad.

11.25.2.6.3 Door frame markings.

The top and sides of the door frame shall be marked with a solid and continuous 25 mm to 51 mm (1-inch- to 2-inch-wide) stripe. Where the door molding does not provide sufficient flat surface on which to locate the stripe, the stripe shall be permitted to be located on the wall surrounding the frame.

11.25.3 Uniformity.

Placement and dimensions of markings shall be consistent and uniform throughout the same enclosure.

11.25.4 Self-luminous and photoluminescent.

Luminous escape path markings shall be permitted to be made of any material, including paint, provided that an electrical charge is not required to maintain the required luminance. Such materials shall include, but not be limited to, self-luminous materials and photoluminescent materials. Materials shall comply with either of the following standards:
1. ASTM E2072, except that the charging source shall be 1 footcandle (11 lux) of fluorescent illumination for 60 minutes, and the minimum luminance shall be 30 milicandelas per square meter at 10 minutes and 5 milicandelas per square meter after 90 minutes.

11.25.5 Illumination.

Where photoluminescent exit path markings are installed, they shall be provided with not less than 1 footcandle (11 lux) of illumination for not less than 60 minutes prior to periods when the building is occupied and continuously during occupancy.

11.26 HORIZONTAL EXITS

11.26.1 Horizontal exits.

Horizontal exits serving as an exit in a means of escape system shall comply with the requirements of this Clause. A horizontal exit shall not serve as the only exit from a portion of a building, and where two or more exits are required, not more than one-half of the total number of exits or total exit minimum width or required capacity shall be horizontal exits.

Exceptions:

1. Horizontal exits are permitted to comprise two-thirds of the required exits from any building or floor area for occupancies in Group I-2.

2. Horizontal exits are permitted to comprise 100 percent of the exits required for occupancies in Group I-3. Not less than 0.6 m² (6 square feet) of accessible space per occupant shall be provided on each side of the horizontal exit for the total number of people in adjoining compartments.

11.26.2 Separation.

The separation between buildings or refuge areas connected by a horizontal exit shall be provided by a fire wall complying with Clause 8.6; or by a fire barrier complying with Clause 8.7 or a horizontal assembly complying with Clause 8.11, or both. The minimum fire-resistance rating of the separation shall be 2 hours. Opening protectives in horizontal exits shall also comply with Clause 8.16. Duct and air transfer openings in a fire wall or fire barrier that serves as a horizontal exit shall also comply with Clause 8.17. The horizontal exit separation shall extend vertically through all levels of the building unless floor assemblies have a fire-resistance rating of not less than 2 hours and do not have unprotected openings.

Exception: A fire-resistance rating is not required at horizontal exits between a building area and an above-grade pedestrian walkway constructed in accordance with Clause 32.4, provided that the distance between connected buildings is more than 6096 mm (20 feet).

Horizontal exits constructed as fire barriers shall be continuous from exterior wall to exterior wall so as to divide completely the floor served by the horizontal exit.

11.26.3 Opening protectives.

Fire doors in horizontal exits shall be self-closing or automatic-closing when activated by a smoke detector in accordance with Clause 8.16.2.6.6. Doors, where located in a cross-corridor condition, shall be automatic-closing by activation of a smoke detector installed in accordance with Clause 8.16.2.6.6.

11.26.4 Refuge area.

The refuge area of a horizontal exit shall be a space occupied by the same tenant or a public area and each such refuge area shall be adequate to accommodate the original occupant load of the refuge area plus the occupant load anticipated from the adjoining compartment. The anticipated occupant load from the adjoining compartment shall be based on the capacity of the horizontal exit doors entering the refuge area or the total occupant load of the adjoining compartment, whichever is less.

11.26.4.1 Capacity.

The capacity of the refuge area shall be computed based on a net floor area allowance of 0.2787 m² (3 square feet) for each occupant to be accommodated therein. Where the horizontal exit also forms a smoke compartment, the capacity of the refuge area for Group I-1, I-2 and I-3 occupancies and Group B ambulatory care facilities shall comply with Clauses 4.7.5.3, 4.8.6.2, 4.20.6.1 and 4.22.3.2 as applicable.
11.26.4.2 Number of exits.

The refuge area into which a horizontal exit leads shall be provided with exits adequate to meet the occupant requirements of this part, but not including the added occupant load imposed by persons entering the refuge area through horizontal exits from other areas. Not less than one refuge area exit shall lead directly to the exterior or to an interior exit stairway or ramp.

Exception: The adjoining compartment shall not be required to have a stairway or door leading directly outside, provided that the refuge area into which a horizontal exit leads has stairways or doors leading directly outside and are so arranged that escape shall not require the occupants to return through the compartment from which escape originates.

11.26.5 Standpipes.

Standpipes and Fire hydrant hose connections shall be provided where required by Clauses 10.5.3 and 10.5.4.

11.27 EXTERIOR EXIT STAIRWAYS AND RAMPS

11.27.1 Exterior exit stairways and ramps.

Exterior exit stairways and ramps serving as an element of a required means of escape shall comply with this Clause.

11.27.2 Use in a means of Escape.

Exterior exit stairways shall not be used as an element of a required means of escape for Group I-2 occupancies. For occupancies in other than Group I-2, exterior exit stairways and ramps shall be permitted as an element of a required means of escape for buildings not exceeding six stories above grade plane or that are not high-rise buildings.

11.27.3 Open side.

Exterior exit stairways and ramps serving as an element of a required means of escape shall be open on not less than one side, except for required structural columns, beams, handrails and guards. An open side shall have not less than 3.3 m² (35 square feet) of aggregate open area adjacent to each floor level and the level of each intermediate landing. The required open area shall be located not less than 1067 mm (42 inches) above the adjacent floor or landing level.

1027.4 Side yards.

The open areas adjoining exterior exit stairways or ramps shall be either yards, courts or public ways; the remaining sides are permitted to be enclosed by the exterior walls of the building.

11.27.5 Location.

Exterior exit stairways and ramps shall have a minimum fire separation distance of 3048 mm (10 feet) measured at right angles from the exterior edge of the stairway or ramps, including landings, to:

1. Adjacent plot lines.

2. Other portions of the building.

3. Other buildings on the same plot unless the adjacent building exterior walls and openings are protected in accordance with Clause 8.5 based on fire separation distance.

For the purposes of this Clause, other portions of the building shall be treated as separate buildings.

Exception: Exterior exit stairways and ramps serving individual dwelling units of Group R-3 shall have a minimum fire separation distance of 1525 mm (5 feet).

11.27.6 Exterior exit stairway and ramp protection.

Exterior exit stairways and ramps shall be separated from the interior of the building as required in Clause 11.23.2. Openings shall be limited to those necessary for escape from normally occupied spaces. Where a vertical plane projecting from the edge of an exterior exit stairway or ramp and landings is exposed by other parts of the building at an angle of less than 180 degrees (3.14 rad), the exterior wall shall be rated in accordance with Clause 11.23.7.

Exceptions:

1. Separation from the interior of the building is not required for occupancies, other than those in Group R-1 or R-2, in buildings that are
not more than two stories above grade plane where a level of exit discharge serving such occupancies is the first storey above grade plane.

2. Separation from the interior of the building is not required where the exterior exit stairway or ramp is served by an exterior exit ramp or balcony that connects two remote exterior exit stairways or other approved exits with a perimeter that is not less than 50 percent open. To be considered open, the opening shall be not less than 50 percent of the height of the enclosing wall, with the top of the openings not less than 2134 mm (7 feet) above the top of the balcony.

4. Separation from the open-ended corridor of the building is not required for exterior exit stairways or ramps, provided that Items 3.1 through 3.5 are met:

4.1. The building, including open-ended corridors, and stairways and ramps, shall be equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2.

4.2. The open-ended corridors comply with Clause 11.20.

4.3. The open-ended corridors are connected on each end to an exterior exit stairway or ramp complying with Clause 11.27.

4.4. The exterior walls and openings adjacent to the exterior exit stairway or ramp comply with Clause 11.23.7.

4.5. At any location in an open-ended corridor where a change of direction exceeding 45 degrees (0.79 rad) occurs, a clear opening of not less than 3.3 m² (35 square feet) or an exterior stairway or ramp shall be provided. Where clear openings are provided, they shall be located so as to minimize the accumulation of smoke or toxic gases.

5. In Group R-3 occupancies not more than four stories in height, exterior exit stairways and ramps serving individual dwelling units are not required to be separated from the interior of the building where the exterior exit stairway or ramp discharges directly to grade.

11.28 FINAL EXIT

11.28.1 General.

Exits shall discharge directly to the exterior of the building. The exit discharge shall be at grade or shall provide a direct path of escape travel to grade. The exit discharge shall not reenter a building. The combined use of Exceptions 1 and 2 shall not exceed 50 percent of the number and minimum width or required capacity of the required exits.

Exceptions:

1. Not more than 50 percent of the number and minimum width or required capacity of interior exit stairways and ramps is permitted to escape through areas on the level of discharge provided that all of the following conditions are met:

1.1. Discharge of interior exit stairways and ramps shall be provided with a free and unobstructed path of travel to an exterior exit door and such exit is readily visible and identifiable from the point of termination of the enclosure.

1.2. The entire area of the level of exit discharge is separated from areas below by construction conforming to the fire-resistance rating for the enclosure.

1.3. The Escape path from the interior exit stairway and ramp on the level of exit discharge is protected throughout by an approved automatic sprinkler system. Portions of the level of exit discharge with access to the escape path shall be either equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1 or 10.3.3.1.2, or separated from the escape path in accordance with the requirements.
for the enclosure of interior exit stairways or ramps.

1.4. Where a required interior exit stairway or ramp and an exit access stairway or ramp serve the same floor level and terminate at the same level of exit discharge, the termination of the exit access stairway or ramp and the exit discharge door of the interior exit stairway or ramp shall be separated by a distance of not less than 9144 mm (30 feet) or not less than one-fourth the length of the maximum overall diagonal dimension of the building, whichever is less. The distance shall be measured in a straight line between the exit discharge door from the interior exit stairway or ramp and the last tread of the exit access stairway or termination of slope of the exit access ramp.

2. Not more than 50 percent of the number and minimum width or required capacity of the interior exit stairways and ramps is permitted to escape through a vestibule provided that all of the following conditions are met:

2.1. The entire area of the vestibule is separated from areas below by construction conforming to the fire-resistance rating of the interior exit stairway or ramp enclosure.

2.2. The depth from the exterior of the building is not greater than 3048 mm (10 feet) and the length is not greater than 9144 mm (30 feet).

2.3. The area is separated from the remainder of the level of exit discharge by a fire partition constructed in accordance with Clause 8.8.

Exception: The maximum transmitted temperature rise is not required.

2.4. The area is used only for means of escape and exits directly to the outside.

3. Horizontal exits complying with Clause 11.26 shall not be required to discharge directly to the exterior of the building.

11.28.2 Exit discharge width or capacity.

The minimum width or required capacity of the exit discharge shall be not less than the minimum width or required capacity of the exits being served.

11.28.3 Exit discharge components.

Exit discharge components shall be sufficiently open to the exterior so as to minimize the accumulation of smoke and toxic gases.

1028.4 Escape courts.

Escape courts serving as a portion of the exit discharge in the means of Escape system shall comply with the requirements of Clauses 11.28.4.1 and 11.28.4.2.

11.28.4.1 Width or capacity.

The required capacity of escape courts shall be determined as specified in Clause 11.5.1, but the minimum width shall be not less than 1118 mm (44 inches), except as specified herein. Escape courts serving Group R-3 and U occupancies shall be not less than 914 mm (36 inches) in width. The required capacity and width of Escape courts shall be unobstructed to a height of 2134 mm (7 feet).

The width of the escape court shall be not less than the required capacity.

Exception: Encroachments complying with Clause 11.5.7.

11.28.4.2 Construction and openings.

Where an Escape court serving a building or portion thereof is less than 3048 mm (10 feet) in width, the Escape court walls shall have not less than 1-hour fire-resistance-rated construction for a distance of 3048 mm (10 feet) above the floor of the escape court. Openings within such walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour.

Exceptions:

1. Escape courts serving an occupant load of less than 10.
2. Escape courts serving Group R-3.

11.28.5 Access to a public way.
The exit discharge shall provide a direct and unobstructed access to a public way.

Exception: Where access to a public way cannot be provided, a safe dispersal area shall be provided where all of the following are met:

1. The area shall be of a size to accommodate not less than 0.46 m² (5 square feet) for each person.

2. The area shall be located on the same plot not less than 15 240 mm (50 feet) away from the building requiring escape.

3. The area shall be permanently maintained and identified as a safe dispersal area.

4. The area shall be provided with a safe and unobstructed path of travel from the building.

11.29 ASSEMBLY

11.29.1 General.
A room or space used for assembly purposes that contains seats, tables, displays, equipment or other material shall comply with this Clause.

11.29.1.1 Bleachers.
Bleachers, grandstands and folding and telescopic seating, that are not building elements, shall comply with this Code.

11.29.1.1.1 Spaces under grandstands and bleachers.
Spaces under grandstands or bleachers shall be separated by fire barriers complying with Clause 8.7 and horizontal assemblies complying with Clause 8.11 with not less than 1-hour fire-resistance-rated construction.

Exceptions:

1. Ticket booths less than 9.29 m² (100 square feet) in area.

2. Toilet rooms.

3. Other accessory use areas 92.9 m² (1,000 square feet) or less in area and equipped with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

11.29.2 Assembly main exit.
A building, room or space used for assembly purposes that has an occupant load of greater than 300 and is provided with a main exit, that main exit shall be of sufficient capacity to accommodate not less than one-half of the occupant load, but such capacity shall be not less than the total required capacity of all means of Escape leading to the exit. Where the building is classified as a Group A occupancy, the main exit shall front on not less than one street or an unoccupied space of not less than 3048 mm (10 feet) in width that adjoins a street or public way. In a building, room or space used for assembly purposes where there is not a well-defined main exit or where multiple main exits are provided, exits shall be permitted to be distributed around the perimeter of the building provided that the total capacity of escape is not less than 100 percent of the required capacity.

11.29.3 Assembly other exits.
In addition to having access to a main exit, each level in a building used for assembly purposes having an occupant load greater than 300 and provided with a main exit, shall be provided with additional means of escape that shall provide an escape capacity for not less than one-half of the total occupant load served by that level and shall comply with Clause 11.7.1. In a building used for assembly purposes where there is not a well-defined main exit or where multiple main exits are provided, exits for each level shall be permitted to be distributed around the perimeter of the building, provided that the total width of escape is not less than 100 percent of the required width.

11.29.4 Foyers and lobbies.
In Group A-1 occupancies, where persons are admitted to the building at times when seats are not available, such persons shall be allowed to wait in a lobby or similar space, provided that such lobby or similar space shall not encroach on the minimum width or required
capacity of the means of escape. Such foyer, if not directly connected to a public street by all the main entrances or exits, shall have a straight and unobstructed corridor or path of travel to every such main entrance or exit.

11.29.5 Interior balcony and gallery means of escape.

For balconies, galleries or press boxes having a seating capacity of 50 or more located in a building, room or space used for assembly purposes, not less than two means of escape shall be provided, with one from each side of every balcony, gallery or press box.

11.29.6 Capacity of aisle for assembly.

The required capacity of aisles shall be not less than that determined in accordance with Clause 11.29.6.1 where smoke-protected assembly seating is not provided, Clause 11.29.6.2 where smoke-protected assembly seating is provided and Clause 11.29.6.3 where open-air assembly seating is provided.

11.29.6.1 Without smoke protection.

The required capacity in mm (inches) of the aisles for assembly seating without smoke protection shall be not less than the occupant load served by the escape element in accordance with all of the following, as applicable:

1. Not less than 7.6 mm (0.3 inch) of aisle capacity for each occupant served shall be provided on stepped aisles having riser heights 178 mm (7 inches) or less and tread depths 279 mm (11 inches) or greater, measured horizontally between tread nosings.

2. Not less than 0.127 mm (0.005 inch) of additional aisle capacity for each occupant shall be provided for each 2.5 mm (0.10 inch) of riser height above 178 mm (7 inches).

3. Where escape requires stepped aisle descent, not less than 1.9 mm (0.075 inch) of additional aisle capacity for each occupant shall be provided on those portions of aisle capacity that do not have a handrail within a horizontal distance of 762 mm (30 inches).

4. Ramped aisles, where slopes are steeper than one unit vertical in 12 units horizontal (8-percent slope), shall have not less than 5.6 mm (0.22 inch) of clear aisle capacity for each occupant served. Level or ramped aisles, where slopes are not steeper than one unit vertical in 12 units horizontal (8-percent slope), shall have not less than 5.1 mm (0.20 inch) of clear aisle capacity for each occupant served.

11.29.6.2 Smoke-protected assembly seating.

The required capacity in inches (mm) of the aisle for smoke-protected assembly seating shall be not less than the occupant load served by the escape element multiplied by the appropriate factor in Table 11.29.6.2. The total number of seats specified shall be those within the space exposed to the same smoke-protected environment. Interpolation is permitted between the specific values shown. A life safety evaluation, complying with the Ghana Fire Code, shall be done for a facility utilizing the reduced width requirements of Table 11.29.6.2 for smoke-protected assembly seating.

Exception: For open-air assembly seating with an occupant load not greater than 18,000, the required capacity in inches (mm) shall be determined using the factors in Clause 11.29.6.3.

<table>
<thead>
<tr>
<th>TABLE 11.29.6.2 CAPACITY FOR AISLES FOR SMOKE-PROTECTED ASSEMBLY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL NUMBER OF SEATS IN THE SMOKE-PROTECTED ASSEMBLY SEATING</strong></td>
</tr>
<tr>
<td>Stepped aisles with handrails within 30 inches</td>
</tr>
</tbody>
</table>

452
11.29.6.2.1 Smoke control.

Aisles and aisle accessways serving a smoke-protected assembly seating area shall be provided with a smoke control system complying with Clause 10.9 or natural ventilation designed to maintain the smoke level not less than 1829 mm (6 feet) above the floor of the means of escape.

11.29.6.2.2 Roof height.

A smoke-protected assembly seating area with a roof shall have the lowest portion of the roof deck not less than 4572 mm (15 feet) above the highest aisle or aisle accessway.

Exception: A roof canopy in an outdoor stadium shall be permitted to be less than 4572 mm (15 feet) above the highest aisle or aisle accessway provided that there are no objects less than 2032 mm (80 inches) above the highest aisle or aisle accessway.

11.29.6.3 Automatic sprinklers.

Enclosed areas with walls and ceilings in buildings or structures containing smoke-protected assembly seating shall be protected with an approved automatic sprinkler system in accordance with Clause 10.3.3.1.1.

Exceptions:

1. The floor area used for contests, performances or entertainment provided that the roof construction is more than 15 240 mm (50 feet) above the floor level and the use is restricted to low fire hazard uses.

2. Press boxes and storage facilities less than 93 m² (1,000 square feet) in area.

3. Outdoor seating facilities where seating and the means of escape in the seating area are essentially open to the outside.

11.29.6.3 Open-air assembly seating.

In open-air assembly seating, the required capacity in mm (inches) of aisles shall be not less than the total occupant load served by the escape element multiplied by 2.0 mm (0.08) where Escape is by stepped aisle and multiplied by 1.52 mm (0.06) where escape is by level aisles and ramped aisles.

Exception: The required capacity in inches (mm) of aisles shall be permitted to comply with Clause 11.29.6.2 for the number of seats in the open-air assembly seating where Clause 11.29.6.2 permits less capacity.

11.29.7 Travel distance.

The exit access travel distance shall comply with Clause 11.17. Where aisles are provided for seating, the distance shall be measured along the aisles and aisle accessways without travel over or on the seats.

Exceptions:

1. In facilities with smoke-protected assembly seating, the total exit access travel distance shall be not greater than 122 m (400 feet). That portion of the total permitted travel distance from each seat to the nearest entrance to a vomitory or concourse shall not exceed 60 960 mm (200 feet). The portion of the total permitted travel distance from the entrance to the vomitory or concourse to one of the following shall not exceed 60 960 mm (200 feet):

   1.1. The closest riser of an exit access stairway.
1.2. The closest slope of an exit access ramp.

1.3. An exit.

2. In facilities with open-air assembly seating of Type II, III or IV construction, the total exit access travel distance to one of the following shall not exceed 122 m (400 feet):

2.1. The closest riser of an exit access stairway.

2.2. The closest slope of an exit access ramp.

2.3. An exit.

3. In facilities with open-air assembly seating of Type I or II construction, the total exit access travel distance shall not be limited.

11.29.8 Common path of Escape travel.

The common path of escape travel shall not exceed 9144 mm (30 feet) from any seat to a point where an occupant has a choice of two paths of escape travel to two exits.

Exceptions:

1. For areas serving less than 50 occupants, the common path of escape travel shall not exceed 22.860 mm (75 feet).

2. For smoke-protected or open-air assembly seating, the common path of escape travel shall not exceed 15 240 mm (50 feet).

11.29.8.1 Path through adjacent row.

Where one of the two paths of travel is across the aisle through a row of seats to another aisle, there shall be not more than 24 seats between the two aisles, and the minimum clear width between rows for the row between the two aisles shall be 305 mm (12 inches) plus 15.2 mm (0.6 inch) for each additional seat.

11.29.9 Assembly aisles are required.

Every occupied portion of any building, room or space used for assembly purposes that contains seats, tables, displays, similar fixtures or equipment shall be provided with aisles leading to exits or exit access doorways in accordance with this Clause.

11.29.9.1 Minimum aisle width.

The minimum clear width for aisles shall comply with one of the following:

1. Forty-eight inches (1219 mm) for stepped aisles having seating on both sides.

2. Thirty-six inches (914 mm) for stepped aisles having seating on only one side.

3. Exception: Twenty-three inches (584 mm) between a stepped aisle handrail or guard and seating where a stepped aisle is subdivided by a mid-aisle handrail.

4. Twenty-three inches (584 mm) between a stepped aisle handrail or guard and seating where the stepped aisle serves less than 50 seats.

5. Forty-two inches (1067 mm) for level or ramped aisles having seating on both sides.

Exceptions:

1. Thirty-six inches (914 mm) where the aisle serves less than 50 seats.

2. Thirty inches (762 mm) where the aisle serves less than 15 seats and does not serve as part of an accessible route.

3. Exception: Twenty-three inches (584 mm) where the aisle serves less than 50 seats.

4. Thirty-six inches (914 mm) for level or ramped aisles having seating on only one side.
**Exception:** Thirty inches (762 mm) where the aisle serves fewer than 15 seats and does not serve as part of an accessible route.

11.29.9.2 Aisle catchment area.

The aisle shall provide sufficient capacity for the number of persons accommodated by the catchment area served by the aisle. The catchment area served by an aisle is that portion of the total space served by that Clause of the aisle. In establishing catchment areas, the assumption shall be made that there is a balanced use of all means of escape, with the number of persons in proportion to Escape capacity.

11.29.9.3 Converging aisles.

Where aisles converge to form a single path of escape travel, the required capacity of that path shall be not less than the combined required capacity of the converging aisles.

11.29.9.4 Uniform width and capacity.

Those portions of aisles, where Escape is possible in either of two directions, shall be uniform in minimum width or required capacity.

11.29.9.5 Dead-end aisles.

Each end of an aisle shall be continuous to a cross aisle, foyer, doorway, vomitory, concourse or stairway in accordance with Clause 11.29.9.7 having access to an exit.

**Exceptions:**

1. Dead-end aisles shall be not greater than 6096 mm (20 feet) in length.

2. Dead-end aisles longer than 16 rows are permitted where seats beyond the 16th row dead-end aisle are not more than 24 seats from another aisle, measured along a row of seats having a minimum clear width of 305 mm (12 inches) plus 15.2 mm (0.6 inch) for each additional seat above seven in the row where seats have backrests or beyond 10 where seats are without backrests in the row.

3. For smoke-protected or open-air assembly seating, the dead-end aisle length of vertical aisles shall not exceed a distance of 21 rows.

4. For smoke-protected or open-air assembly seating, a longer dead-end aisle is permitted where seats beyond the 21-row dead-end aisle are not more than 40 seats from another aisle, measured along a row of seats having an aisle accessway with a minimum clear width of 305 mm (12 inches) plus 7.6 mm (0.3 inch) for each additional seat above seven in the row where seats have backrests or beyond 10 where seats are without backrests in the row.

11.29.9.6 Aisle measurement.

The clear width for aisles shall be measured to walls, edges of seating and tread edges except for permitted projections.

**Exception:** The clear width of aisles adjacent to seating at tables shall be permitted to be measured in accordance with Clause 11.29.13.1.

11.29.9.6.1 Assembly aisle obstructions.

There shall not be obstructions in the minimum width or required capacity of aisles.

**Exception:** Handrails are permitted to project into the required width of stepped aisles and ramped aisles in accordance with Clause 11.14.8.

11.29.9.7 Stairways connecting to stepped aisles.

A stairway that connects a stepped aisle to a cross aisle or concourse shall be permitted to comply with the assembly aisle walking surface requirements of Clause 11.29.14. Transitions between stairways and stepped aisles shall comply with Clause 11.29.10.

11.29.9.8 Stairways connecting to vomitories.

A stairway that connects a vomitory to a cross aisle or concourse shall be permitted to comply with the assembly aisle walking surface requirements of Clause 11.29.14. Transitions between stairways and stepped aisles shall comply with Clause 11.29.10.
11.29.10 Transitions.

Transitions between stairways and stepped aisles shall comply with either Clause 11.29.10.1 or 11.29.10.2.

11.29.10.1 Transitions to stairways that maintain stepped aisle riser and tread dimensions.

Stepped aisles, transitions and stairways that maintain the stepped aisle riser and tread dimensions shall comply with Clause 11.29.14 as one exit access component.

11.29.10.2 Transitions to stairways that do not maintain stepped aisle riser and tread dimensions.

Transitions between stairways and stepped aisles having different riser and tread dimensions shall comply with Clauses 11.29.10.2.1 through 11.29.10.3.

11.29.10.2.1 Stairways and stepped aisles in a straight run.

Where stairways and stepped aisles are in a straight run, transitions shall have one of the following:

1. A depth of not less than 559 mm (22 inches) where the treads on the descending side of the transition have greater depth.

2. A depth of not less than 762 mm (30 inches) where the treads on the descending side of the transition have lesser depth.

11.29.10.2.2 Stairways that change direction from stepped aisles.

Transitions where the stairway changes direction from the stepped aisle shall have a minimum depth of 11 inches (280 mm) or the stepped aisle tread depth, whichever is greater, between the stepped aisle and stairway.

11.29.10.3 Transition marking.

A distinctive marking stripe shall be provided at each nosing or leading edge adjacent to the transition. Such stripe shall be not less than 25 mm (1 inch), and not more than 51 mm (2 inches), wide. The edge marking stripe shall be distinctively different from the stepped aisle contrasting marking stripe.

11.29.11 Stepped aisles at vomitories.

Stepped aisles that change direction at vomitories shall comply with Clause 11.29.11.1 Transitions between a stepped aisle above a vomitory and a stepped aisle to the side of a vomitory shall comply with Clause 11.29.11.2.

11.29.11.1 Stepped aisles that change direction at vomitories.

Stepped aisle treads where the stepped aisle changes direction at a vomitory shall have a depth of not less than 280 mm (11 inches) or the stepped aisle tread depth, whichever is greater. The height of a stepped aisle tread above a transition at a vomitory shall comply with Clause 11.29.14.2.2.

11.29.11.2 Stepped aisle transitions at the top of vomitories.

Transitions between the stepped aisle above a vomitory and stepped aisles to the side of a vomitory shall have a depth of not less than 280 mm (11 inches) or the stepped aisle tread depth, whichever is greater.

11.29.12 Construction.

Aisles, stepped aisles and ramped aisles shall be built of materials consistent with the types permitted for the type of construction of the building.

Exception: Wood handrails shall be permitted for all types of construction.

11.29.12.1 Walking surface.

The surface of aisles, stepped aisles and ramped aisles shall be of slip-resistant materials that are securely attached. The surface for stepped aisles shall comply with Clause 11.11.7.1.
11.29.12.2 Outdoor conditions.

Outdoor aisles, stepped aisles and ramped aisles and outdoor approaches to aisles, stepped aisles and ramped aisles shall be designed so that water will not accumulate on the walking surface.

11.29.13 Aisle accessways.

Aisle accessways for seating at tables shall comply with Clause 11.29.13.1. Aisle accessways for seating in rows shall comply with Clause 11.29.13.2.

11.29.13.1 Seating at tables.

Where seating is located at a table or counter and is adjacent to an aisle or aisle accessway, the measurement of required clear width of the aisle or aisle accessway shall be made to a line 483 mm (19 inches) away from and parallel to the edge of the table or counter. The 483 mm (19-inch) distance shall be measured perpendicular to the side of the table or counter. In the case of other side boundaries for aisles or aisle accessways, the clear width shall be measured to walls, edges of seating and tread edges.

Exception: Where tables or counters are served by fixed seats, the width of the aisle or aisle accessway shall be measured from the back of the seat.

11.29.13.1.1 Aisle accessway capacity and width for seating at tables.

Aisle accessways serving arrangements of seating at tables or counters shall comply with the capacity requirements of Clause 11.5.1 but shall not have less than 305 mm (12 inches) of width plus 12.7 mm (1/2 inch) of width for each additional 305 mm (1 foot), or fraction thereof, beyond 3658 mm (12 feet) of aisle accessway length measured from the center of the seat farthest from an aisle.

Exception: Portions of an aisle accessway having a length not exceeding 1829 mm (6 feet) and used by a total of not more than four persons.

11.29.13.2 Clear width of aisle accessways serving seating in rows.

Where seating rows have 14 or fewer seats, the minimum clear aisle accessway width shall be not less than 305 mm (12 inches) measured as the clear horizontal distance from the back of the row ahead and the nearest projection of the row behind. Where chairs have automatic or self-rising seats, the measurement shall be made with seats in the raised position. Where any chair in the row does not have an automatic or self-rising seat, the measurements shall be made with the seat in the down position. For seats with folding tablet arms, row spacing shall be determined with the tablet arm in the used position.

Exception: For seats with folding tablet arms, row spacing is permitted to be determined with the tablet arm in the stored position where the tablet arm when raised manually to vertical position in one motion automatically returns to the stored position by force of gravity.

11.29.13.2.1 Dual access.

For rows of seating served by aisles or doorways at both ends, there shall be not more than 100 seats per row. The minimum clear width of 305 mm (12 inches) between rows shall be increased by 7.6 mm (0.3 inch) for every additional seat beyond 14 seats where seats have backrests or beyond 21 where seats are without backrests. The minimum clear width is not required to exceed 559 mm (22 inches).

Exception: For smoke-protected or open-air assembly seating, the row length limits for a 305 mm (12-inch-wide) aisle accessway, beyond which the aisle accessway minimum clear width shall be increased, are in Table 11.29.13.2.1.
11.29.13.2.2 Single access.

For rows of seating served by an aisle or doorway at only one end of the row, the minimum clear width of 305 mm (12 inches) between rows shall be increased by 15.2 mm (0.6 inch) for every additional seat beyond seven seats where seats have backrests or beyond 10 where seats are without backrests. The minimum clear width is not required to exceed 559 mm (22 inches).

**Exception:** For smoke-protected or open-air assembly seating, the row length limits for a 305 mm (12-inch-wide) aisle accessway, beyond which the aisle accessway minimum clear width shall be increased, are in Table 1029.13.2.1.

### Table 1029.13.2.1

| TOTAL NUMBER OF SEATS IN THE SMOKE-PROTECTED OR OPEN-AIR ASSEMBLY SEATING | MAXIMUM NUMBER OF SEATS PER ROW PERMITTED TO HAVE A MINIMUM 12-INCH CLEAR WIDTH AISLE ACCESSWAY |
|---|---|---|---|
| Aisle or doorway at both ends of row | Aisle or doorway at one end of row only |
| Seats with backrests | Seats without backrests | Seats with backrests | Seats without backrests |
| Less than 4,000 | 14 | 21 | 7 | 10 |
| 4,000 | 15 | 22 | 7 | 10 |
| 7,000 | 16 | 23 | 8 | 11 |
| 10,000 | 17 | 24 | 8 | 11 |
| 13,000 | 18 | 25 | 9 | 12 |
| 16,000 | 19 | 26 | 9 | 12 |
| 19,000 | 20 | 27 | 10 | 13 |
| 22,000 and greater | 21 | 28 | 11 | 14 |

**Note:** For SI: 1 inch = 25.4 mm.

11.29.14 Assembly aisle walking surfaces.


11.29.14.1 Ramped aisles.

Aisles that are sloped more than one unit vertical in 20 units horizontal (5-percent slope) shall be considered to be a ramped aisle. Ramped aisles that serve as part of an accessible route in accordance with Clauses 11.9 and 12.8.2 shall have a maximum slope of one unit vertical in 12 units horizontal (8-percent slope). The slope of other ramped aisles shall not exceed one unit vertical in 8 units horizontal (12.5-percent slope).

11.29.14.1.1 Cross slope.

The slope measured perpendicular to the direction of travel of a ramped aisle shall not be steeper than one unit vertical in 48 units horizontal (2-percent slope).

11.29.14.1.2 Landings.

Ramped aisles shall have landings in accordance with Clauses 11.12.6 through 11.12.6.5. Landings for ramped aisles shall be permitted to overlap required aisles or cross aisles.

11.29.14.1.3 Edge protection.

Ramped aisles shall have edge protection in accordance with Clauses 11.12.10 and 11.12.10.1.

**Exception:** In assembly spaces with fixed seating, edge protection is not required on the sides of ramped aisles where the ramped aisles provide access to the adjacent seating and aisle accessways.

11.29.14.2 Stepped aisles.

Aisles with a slope exceeding one unit vertical in eight units horizontal (12.5-percent slope) shall consist of a series of risers and treads that extends across the full width of aisles and complies with Clauses 11.29.14.2.1 through 11.29.14.2.4.

11.29.14.2.1 Treads.

Tread depths shall be not less than 279 mm (11 inches) and shall have dimensional uniformity.
Exception: The tolerance between adjacent treads shall not exceed 4.8 mm (3/16 inch).

11.29.14.2.2 Risers.
Where the gradient of stepped aisles is to be the same as the gradient of adjoining seating areas, the riser height shall be not less than 102 mm (4 inches) nor more than 203 mm (8 inches) and shall be uniform within each flight.

Exceptions:

1. Riser height nonuniformity shall be limited to the extent necessitated by changes in the gradient of the adjoining seating area to maintain adequate sightlines. Where nonuniformities exceed 4.8 mm (3/16 inch) between adjacent risers, the exact location of such nonuniformities shall be indicated with a distinctive marking stripe on each tread at the nosing or leading edge adjacent to the nonuniform risers. Such stripe shall be not less than 25 mm (1 inch), and not more than 51 mm (2 inches), wide. The edge marking stripe shall be distinctively different from the contrasting marking stripe.

2. Riser heights not exceeding 229 mm (9 inches) shall be permitted where they are necessitated by the slope of the adjacent seating areas to maintain sightlines.

11.29.14.2.2.1 Construction tolerances.
The tolerance between adjacent risers on a stepped aisle that were designed to be equal height shall not exceed 4.8 mm (3/16 inch). Where the stepped aisle is designed in accordance with Exception 1 of Clause 11.29.14.2.2, the stepped aisle shall be constructed so that each riser of unequal height, determined in the direction of descent, is not more than 9.5 mm (3/8 inch) in height different from adjacent risers where stepped aisle treads are less than 560 mm (22 inches) in depth and 19.1 mm (3/4 inch) in height different from adjacent risers where stepped aisle treads are 560 mm (22 inches) or greater in depth.

11.29.14.2.3 Tread contrasting marking stripe.
A contrasting marking stripe shall be provided on each tread at the nosing or leading edge such that the location of each tread is readily apparent when viewed in descent. Such stripe shall be not less than 25 mm (1 inch) and not more than 51 mm (2 inches) wide.

Exception: The contrasting marking stripe is permitted to be omitted where tread surfaces are such that the location of each tread is readily apparent when viewed in descent.

11.29.14.2.4 Nosing and profile.
Nosing and riser profile shall comply with Clauses 11.11.5.5 through 11.11.5.5.3.

11.29.15 Seat stability.
In a building, room or space used for assembly purposes, the seats shall be securely fastened to the floor.

Exceptions:

1. In a building, room or space used for assembly purposes or portions thereof without ramped or tiered floors for seating and with 200 or fewer seats, the seats shall not be required to be fastened to the floor.

2. In a building, room or space used for assembly purposes or portions thereof with seating at tables and without ramped or tiered floors for seating, the seats shall not be required to be fastened to the floor.

3. In a building, room or space used for assembly purposes or portions thereof without ramped or tiered floors for seating and with greater than 200 seats, the seats shall be fastened together in groups of not less than three or the seats shall be securely fastened to the floor.

4. In a building, room or space used for assembly purposes where flexibility of the seating arrangement is an integral part of the design and function of the space and seating is on tiered levels,
not more than 200 seats shall not be required to be fastened to the floor. Plans showing seating, tiers and aisles shall be submitted for approval.

5. Groups of seats within a building, room or space used for assembly purposes separated from other seating by railings, guards, partial height walls or similar barriers with level floors and having not more than 14 seats per group shall not be required to be fastened to the floor.

6. Seats intended for musicians or other performers and separated by railings, guards, partial height walls or similar barriers shall not be required to be fastened to the floor.

11.29.16 Handrails.

Ramped aisles having a slope exceeding one unit vertical in 15 units horizontal (6.7-percent slope) and stepped aisles shall be provided with handrails in compliance with Clause 11.14 located either at one or both sides of the aisle or within the aisle width.

Exceptions:

1. Handrails are not required for ramped aisles with seating on both sides.

2. Handrails are not required where, at the side of the aisle, there is a guard with a top surface that complies with the graspability requirements of handrails in accordance with Clause 11.14.3.

3. Handrail extensions are not required at the top and bottom of stepped aisles and ramped aisles to permit crossovers within the aisles.

11.29.16.1 Discontinuous handrails.

Where there is seating on both sides of the aisle, the mid-aisle handrails shall be discontinuous with gaps or breaks at intervals not exceeding five rows to facilitate access to seating and to permit crossing from one side of the aisle to the other. These gaps or breaks shall have a clear width of not less than 559 mm (22 inches) and not greater than 914 mm (36 inches), measured horizontally, and the mid-aisle handrail shall have rounded terminations or bends.

11.29.16.2 Handrail termination.

Handrails located on the side of stepped aisles shall return to a wall, guard or the walking surface or shall be continuous to the handrail of an adjacent stepped aisle flight.

11.29.16.3 Mid-aisle termination.

Mid-aisle handrails shall not extend beyond the lowest riser and shall terminate within 381 mm (18 inches), measured horizontally, from the lowest riser. Handrail extensions are not required. Exception: Mid-aisle handrails shall be permitted to extend beyond the lowest riser where the handrail extensions do not obstruct the width of the cross aisle.

11.29.16.4 Rails.

Where mid-aisle handrails are provided in stepped aisles, there shall be an additional rail located approximately 305 mm (12 inches) below the handrail. The rail shall be adequate in strength and attachment in accordance with Clause 17.7.8.1.2.

11.29.17 Assembly guards.

Guards adjacent to seating in a building, room or space used for assembly purposes shall be provided where required by Clause 11.15 and shall be constructed in accordance with Clause 11.15 except where provided in accordance with Clauses 11.29.17.1 through 11.29.17.4. At bleachers, grandstands and folding and telescopic seating, guards must be provided where required by this Code and Clause 11.29.17.1.

11.29.17.1 Perimeter guards.

Perimeter guards shall be provided where the footboards or walking surface of seating facilities are more than 762 mm (30 inches) above the floor or grade below. Where the seatboards are adjacent to the perimeter, guard height shall be 1067 mm (42 inches) high minimum, measured from the seatboard. Where the seats are self-rising, guard height shall be 1067 mm (42 inches) high minimum, measured from the floor surface. Where there is an aisle between the seating and the perimeter, the guard height shall be measured in accordance with Clause 11.15.3.
Exceptions:

1. Guards that impact sightlines shall be permitted to comply with Clause 11.29.17.3.

2. Bleachers, grandstands and folding and telescopic seating shall not be required to have perimeter guards where the seating is located adjacent to a wall and the space between the wall and the seating is less than 102 mm (4 inches).

11.29.17.2 Cross aisles.

Cross aisles located more than 762 mm (30 inches) above the floor or grade below shall have guards in accordance with Clause 11.15.

Where an elevation change of 762 mm (30 inches) or less occurs between a cross aisle and the adjacent floor or grade below, guards not less than 660 mm (26 inches) above the aisle floor shall be provided.

Exception: Where the backs of seats on the front of the cross aisle project 610 mm (24 inches) or more above the adjacent floor of the aisle, a guard need not be provided.

11.29.17.3 Sightline-constrained guard heights.

Unless subject to the requirements of Clause 11.29.17.4, a fascia or railing system in accordance with the guard requirements of Clause 11.15 and having a minimum height of 660 mm (26 inches) shall be provided where the floor or footboard elevation is more than 762 mm (30 inches) above the floor or grade below and the fascia or railing would otherwise interfere with the sightlines of immediately adjacent seating.

11.29.17.4 Guards at the end of aisles.

A fascia or railing system complying with the guard requirements of Clause 11.15 shall be provided for the full width of the aisle where the foot of the aisle is more than 762 mm (30 inches) above the floor or grade below. The fascia or railing shall be not less than 914 mm (36 inches) high and shall provide not less than 1067 mm (42 inches) measured diagonally between the top of the rail and the nosing of the nearest tread.

11.30 EMERGENCY ESCAPE AND RESCUE

11.30.1 General.

In addition to the means of Escape required by this part, emergency escape and rescue openings shall be provided in the following occupancies:

1. Group R-2 occupancies located in stories with only one exit or access to only one exit as permitted by Tables 11.6.3.3(1) and 11.6.3.3(2).

2. Group R-3 and R-4 occupancies.

Basements and sleeping rooms below the fourth storey above grade plane shall have not fewer than one exterior emergency escape and rescue opening in accordance with this Clause. Where basements contain one or more sleeping rooms, emergency escape and rescue openings shall be required in each sleeping room, but shall not be required in adjoining areas of the basement. Such openings shall open directly into a public way or to a yard or court that opens to a public way.

Exceptions:

1. Basements with a ceiling height of less than 2032 mm (80 inches) shall not be required to have emergency escape and rescue openings.

2. Emergency escape and rescue openings are not required from basements or sleeping rooms that have an exit door or exit access door that opens directly into a public way or to a yard, court or exterior exit balcony that opens to a public way.

3. Basements without habitable spaces and having not more than 18.6 m² (200 square feet) in floor area shall not be required to have emergency escape and rescue openings.

4. Within individual dwelling and sleeping units in Groups R-2 and R-3, where the building is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1, 10.3.3.1.2 or 10.3.3.1.3, sleeping rooms in basements shall not be required to have emergency escape and rescue openings provided
that the basement has one of the following:

4.1. One means of escape and one emergency escape and rescue opening.

4.2. Two means of escape.

11.30.1.1 Operational constraints and opening control devices.

Emergency escape and rescue openings shall be operational from inside the room without the use of keys or tools. Window-opening control devices complying with ASTM F2090 shall be permitted for use on windows serving as a required emergency escape and rescue opening.

11.30.2 Minimum size.

Emergency escape and rescue openings shall have a minimum net clear opening of 0.53 m² (5.7 square feet).

Exception: The minimum net clear opening for grade-floor emergency escape and rescue openings shall be 0.46 m² (5 square feet).

11.30.2.1 Minimum dimensions.

The minimum net clear opening height dimension shall be 610 mm (24 inches). The minimum net clear opening width dimension shall be 508 mm (20 inches). The net clear opening dimensions shall be the result of normal operation of the opening.

11.30.3 Maximum height from floor.

Emergency escape and rescue openings shall have the bottom of the clear opening not greater than 1118 mm (44 inches) measured from the floor.

11.30.4 Window wells.

An emergency escape and rescue opening with a finished sill height below the adjacent ground level shall be provided with a window well in accordance with Clauses 11.30.4.1 and 11.30.4.2.

11.30.4.1 Minimum size.

The minimum horizontal area of the window well shall be 0.84 m² (9 square feet), with a minimum dimension of 914 mm (36 inches). The area of the window well shall allow the emergency escape and rescue opening to be fully opened.

11.30.4.2 Ladders or steps.

Window wells with a vertical depth of more than 1118 mm (44 inches) shall be equipped with an approved permanently affixed ladder or steps. Ladders or rungs shall have an inside width of not less than 305 mm (12 inches), shall project not less than 76 mm (3 inches) from the wall and shall be spaced not more than 457 mm (18 inches) on center (o.c.) vertically for the full height of the window well. The ladder or steps shall not encroach into the required dimensions of the window well by more than 152 mm (6 inches). The ladder or steps shall not be obstructed by the emergency escape and rescue opening. Ladders or steps required by this Clause are exempt from the stairway requirements of Clause 11.11.

11.30.5 Bars, grilles, covers and screens.

Bars, grilles, covers, screens or similar devices are permitted to be placed over emergency escape and rescue openings, bulkhead enclosures or window wells that serve such openings, provided that the minimum net clear opening size complies with Clauses 11.30.1.1 through 11.30.4.2 and such devices shall be releasable or removable from the inside without the use of a key, tool or force greater than that which is required for normal operation of the emergency escape and rescue opening. Where such bars, grilles, covers, screens or similar devices are installed in existing buildings, they shall not reduce the net clear opening of the emergency escape and rescue opening and smoke alarms shall be installed in accordance with Clause 10.7.2.10 regardless of the valuation of the alteration.
PART 12: ACCESSIBILITY

The provisions of this part are contained in the Ghana Accessibility standard GS 1119:2016.
PART 13: INTERIOR ENVIRONMENT

User note:
About this part: Part 13 provides minimum provisions for the interior of buildings—the occupied environment. Ventilation, lighting, and space heating are directly regulated in this part. Minimum room size and maximum room-to-room sound transmission are set for certain occupancies.

13.1 GENERAL

13.1.1 Scope.
The provisions of this part shall govern ventilation, temperature control, lighting, yards and courts, sound transmission, room dimensions, surrounding materials and rodentproofing associated with the interior spaces of buildings.

13.1.2 Indoor air quality management plan required.
An indoor air quality management plan shall be developed. Such plan shall address the methods and procedures to be used during design and construction to obtain compliance with Clauses 13.2 through 13.5.

13.2 BUILDING CONSTRUCTION FEATURES, OPERATIONS AND MAINTENANCE FACILITATION

13.2.1 Scope.
To facilitate the operation and maintenance of the completed building, the building and its systems shall comply with the requirements of Clauses 13.2.2 and 13.2.3.

13.2.2 Air-handling system access.
The arrangement and location of air-handling system components including, but not limited to, ducts, air handler units, fans, coils and condensate pans, shall allow access for cleaning and repair of the air-handling surfaces of such components. Access ports shall be installed in the air-handling system to permit such cleaning and repairs. Piping, conduits, and other building components shall not be located so as to obstruct the required access ports.

13.2.3 Air-handling filtration and bypass pathways.
Air-handling equipment and HVAC equipment shall be designed and installed to limit the amount of airflow that bypasses the air filters and shall comply with the following:

1. Channels, racks and other filter-retaining constructions that do not seal tightly to the filter frame by means of a friction fit shall be provided with a means to seal the filter frame to the filter-retaining construction.

2. Where standard size filters are installed in banks of multiple filters, gaskets shall seal the gap between the frames of adjacent filters.

3. As an alternative to gaskets, the frames of adjacent filters shall be compressed tightly together by means of spring elements that are built into the filter-retaining construction.

4. Channels, racks and other filter-retaining constructions shall be sealed to the duct or housing of the HVAC equipment served by the filters.

5. Filter access doors in ducts and HVAC equipment shall be designed to limit the amount of airflow that bypasses the filters.

6. Field or shop-fabricated spacers shall not be installed for the purpose of replacing the intended size filter with a smaller size filter.

7. Gaskets and seals shall be accessible for repair, maintenance and replacement.

13.3 HVAC SYSTEMS

13.3.1 Construction phase requirements.
The ventilation of buildings during the construction phase shall be in accordance with Clauses 13.3.1.1 through 13.3.1.3.

13.3.1.1 Duct openings.
Duct and other related air distribution component openings shall be covered with tape, plastic or sheet metal, or shall be closed by an approved method to reduce the amount of dust and debris that collects in the system.
from the time of rough-in installation and until startup of the heating and cooling equipment. Dust and debris shall be cleaned from duct openings prior to system flush out and building occupancy.

13.3.1.2 Indoor air quality during construction.
Temporary ventilation during construction shall be provided in accordance with Clauses 13.3.1.2.1 through 13.3.1.2.3.

13.3.1.2.1 Ventilation.
Ventilation during construction shall be achieved through openings in the building envelope using one or more of the following methods:

1. Natural ventilation in accordance with the provisions of the in this Code.
2. Fans that produce a minimum of three air changes per hour.
3. Exhaust in the work area at a rate of not less than 0.05
   \(\text{cfm/ft}^2\) (0.24 L/s/in\(^2\)) and not less than 10 percent greater than the supply air rate so as to maintain negative pressurization of the space.

13.3.1.2.2 Protection of HVAC system openings.
HVAC supply and return duct and equipment openings shall be protected during dust-producing operations.

13.3.1.2.3 Return air filters.
Where a forced air HVAC system is used during construction, new return air filters shall be installed prior to system flush out and building occupancy.

13.3.1.3 Construction phase ductless system or filter.
Where spaces are conditioned during the construction phase, space-conditioning systems shall be of the ductless variety, or filters for ducted systems shall be rated at MERV 8 or higher in accordance with ASHRAE 52.2, and system equipment shall be designed to be compatible. Duct system design shall account for pressure drop across the filter.

13.3.2 Thermal environmental conditions for human occupancy.

Exception: Spaces with special requirements for processes, activities, or contents that require a thermal environment outside of that which humans find thermally acceptable, such as food storage, natatoriums, shower rooms, saunas and drying rooms.

13.3.3 Isolation of pollutant sources.
The isolation of pollutant sources related to print, copy and janitorial rooms shall be in accordance with Clause 13.3.3.1.

13.3.3.1 Printer, copier and janitorial rooms.
Enclosed rooms or spaces that are over 9.3 m\(^2\) (100 square feet) in area and that are used primarily as a print or copy facility containing five or more printers, copy machines, scanners, facsimile machines or similar machines in any combination, and rooms used primarily as janitorial rooms or closets where the use or storage of chemicals occurs, shall comply with all of the following:

1. The enclosing walls shall extend from the floor surface to the underside of the floor, roof deck or solid ceiling above and shall be constructed to resist the passage of airborne chemical pollutants and shall be constructed and sealed as required for 1-hour fire-resistance-rated construction assemblies. Alternatively, for janitorial rooms and closets, all chemicals shall be stored in approved chemical safety storage cabinets.
2. Doors in the enclosing walls shall be automatic or self-closing.
3. An HVAC system shall be provided that: provides separate exhaust airflow to the outdoors at a rate of not less than 0.50 cfm per square foot (2.4 L/s/m\(^2\)); that maintains a negative pressure of not less than 7 Pa within the room; and that prohibits the recirculation of air.
13.3.4 Filters.

Filters for air-conditioning systems that serve occupied spaces shall be rated at MERV 11 or higher, in accordance with ASHRAE Standard 52.2, and system equipment shall be designed to be compatible. The air-handling system design shall account for pressure drop across the filter. The pressure drop across clean MERV 11 filters shall be not greater than 0.45 in. w.c. at 500 fpm (412 Pa at 2.54 m/s) filter face velocity. Filter performance shall be shown on the filter manufacturer's data sheet.

13.4 SPECIFIC INDOOR AIR QUALITY AND POLLUTANT CONTROL MEASURES

13.4.1 Fireplaces and appliances.

Where located within buildings, fireplaces, solid fuel-burning appliances, vented decorative gas appliances, vented gas fireplace heaters and decorative gas appliances for installation in fireplaces shall comply with Clauses 13.4.1.1 through 13.4.1.3. Unvented room heaters and unvented decorative appliances, including alcohol burning, shall be prohibited. Biomass boilers shall be listed and labeled in accordance with CSA B366.1.

13.4.2 Post-construction, pre-occupancy baseline IAQ testing.

Where this clause is indicated to be applicable in this Code, and after all interior finishes are installed, the building shall be tested for indoor air quality and the testing results shall indicate that the levels of VOCs meet the levels detailed in this code using testing protocols in accordance with ASTM D5197, ASTM D5466, ASTM D6196, ASTM D6345, and ISO 7708. Test samples shall be taken in not less than one location in each 1860 m$^2$ (25,000 square feet) of floor area or in each contiguous floor area.

**Exceptions:**

1. Group F, H, I-2, S and U occupancies shall not be required to comply with this clause.

2. A building shall not be required to be tested where a similarly designed and constructed building as determined by the Code official, for the same owner or tenant, has been tested for indoor air quality and the testing results indicate that the level of VOCs meet the levels detailed in Table 13.4.2.

3. Where the building indoor environment does not meet the concentration limits in Table 13.4.2 and the tenant does not address the air quality issue by mitigation and retesting, the building shall be flushed out by supplying continuous ventilation with all air-handling units at their maximum outdoor air rate for at least 14 days while maintaining an internal temperature of at least 60°F (15.6°C), and relative humidity not higher than 60 percent. Occupancy shall be permitted to start 7 days after start of the flush out, provided that the flush out continues for the full 14 days.

13.4.1.1 Venting and combustion air.

Fireplaces and fuel-burning appliances shall be vented to the outdoors and shall be provided with combustion air provided from the outdoors in accordance with this Code. Solid fuel-burning fireplaces shall be provided with a means to tightly close off the chimney flue and combustion air openings when the fireplace is not in use.

13.4.1.2 Wood-fired appliances.

Wood stoves and wood-burning fireplace inserts shall be listed and, additionally, shall be labeled in accordance with the requirements of the EPA Standards of Performance for New Residential Wood Heaters, 40 CFR Part 60, subpart AAA.

13.4.1.3 Biomass appliances.

Biomass fireplaces, stoves and inserts shall be listed and labeled in accordance with ASTM E1509. Biomass furnaces shall be listed and labeled in accordance with CSA B366.1.
### TABLE 13.4.2
MAXIMUM CONCENTRATION OF AIR POLLUTANTS

<table>
<thead>
<tr>
<th>MAXIMUM CONCENTRATION OF AIR POLLUTANTS RELEVANT TO IAQ</th>
<th>MAXIMUM CONCENTRATION, µg/m³ (unless otherwise noted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Methyl-2-pyrrolidinone</td>
<td>160</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>1000</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>20</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>800</td>
</tr>
<tr>
<td>1,4-Dioxane</td>
<td>3000</td>
</tr>
<tr>
<td>2-Ethylhexanoic acid</td>
<td>25</td>
</tr>
<tr>
<td>2-Propanol</td>
<td>7000</td>
</tr>
<tr>
<td>4-Phenylcyclohexene (4-PCH)</td>
<td>2.5</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>140</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>5</td>
</tr>
<tr>
<td>Benzene</td>
<td>60</td>
</tr>
<tr>
<td>t-Butyl methyl ether</td>
<td>8000</td>
</tr>
<tr>
<td>Caprolactam</td>
<td>100</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>800</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>9 ppm and no greater than 2 ppm above outdoor levels</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>40</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>1000</td>
</tr>
<tr>
<td>Chloroform</td>
<td>300</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>400</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>2000</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>400</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>27</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>7000</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>9</td>
</tr>
<tr>
<td>Nonanal</td>
<td>13</td>
</tr>
<tr>
<td>Octanal</td>
<td>7.2</td>
</tr>
<tr>
<td>Particulates (PM 2.5)</td>
<td>35 (24-hr)</td>
</tr>
<tr>
<td>Particulates (PM 10)</td>
<td>150 (24-hr)</td>
</tr>
<tr>
<td>Phenol</td>
<td>200</td>
</tr>
<tr>
<td>Styrene</td>
<td>900</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>35</td>
</tr>
<tr>
<td>Toluene</td>
<td>300</td>
</tr>
<tr>
<td>Total volatile organic compounds (TVOC)</td>
<td>500</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>600</td>
</tr>
<tr>
<td>Xylene isomers</td>
<td>700</td>
</tr>
</tbody>
</table>

a. This chemical has a limit only where carpets and fabrics with styrene butadiene rubber (SBR) latex backing material are installed as part of the base building systems.

1. Asbestos-containing materials.
2. Urea-formaldehyde foam insulation.

### 13.5 PROHIBITED MATERIALS

#### 13.5.1 Scope.
Use of the following materials shall be prohibited:

#### 13.6 MATERIAL EMISSIONS AND POLLUTANT CONTROL
13.6.1 Emissions from composite wood products.

Composite wood products used interior to the approved weather covering of the building shall comply with the emission limits cited in Table 13.6.1. Compliance with emission limits shall be demonstrated following the requirements of this Code.

Exceptions:

1. Composite wood products that are made using adhesives that do not contain urea-formaldehyde (UF) resins.

2. Composite wood products that are sealed with an impermeable material on all sides and edges.

3. Composite wood products that are used to make elements considered to be furniture, fixtures and equipment (FF&E) that are not permanently installed.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>FORMALDEHYDE LIMIT (b ) (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwood plywood</td>
<td>0.05</td>
</tr>
<tr>
<td>Particle board</td>
<td>0.09</td>
</tr>
<tr>
<td>Medium-density fiberboard</td>
<td>0.11</td>
</tr>
<tr>
<td>Thin medium-density fiberboard (a)</td>
<td>0.13</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.


b. Phase 2 Formaldehyde Emissions Standards, this Code; compliance shall be demonstrated in accordance with ASTM D6007 or ASTM E1333.

13.6.2 Adhesives and sealants.

A minimum of 85 percent by weight or volume, of specific categories of site-applied adhesives and sealants used on the interior side of the building envelope, shall comply with the VOC content limits in Table 13.6.2(1) or alternative VOC emission limits in Table 13.6.2(2). The VOC content shall be determined in accordance with the appropriate standard being either SCAQMD Methods 302 and 303 or ASTM D3960. Table 13.6.2(1) adhesives and sealants regulatory category and VOC content compliance determination shall conform to the SCAQMD Rule 1168. The provisions of this clause shall not apply to adhesives and sealants subject to state or federal consumer product VOC regulations. HVAC duct sealants shall be classified as “Other” category within the SCAQMD Rule 1168 sealants table.

**TABLE 13.6.1**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>FORMALDEHYDE LIMIT (b) (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor carpet adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Carpet pad adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Outdoor carpet adhesives</td>
<td>150</td>
</tr>
<tr>
<td>Wood flooring adhesive</td>
<td>100</td>
</tr>
<tr>
<td>Rubber floor adhesives</td>
<td>60</td>
</tr>
<tr>
<td>Subfloor adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Ceramic tile adhesives</td>
<td>65</td>
</tr>
<tr>
<td>VCT and asphalt tile adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Dry wall and panel adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Cove base adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Multipurpose construction adhesives</td>
<td>70</td>
</tr>
<tr>
<td>Structural glazing adhesives</td>
<td>100</td>
</tr>
<tr>
<td>Single-ply roof membrane adhesives</td>
<td>250</td>
</tr>
<tr>
<td>Architectural sealants</td>
<td>250</td>
</tr>
<tr>
<td>Architectural sealant primer Nonporous</td>
<td>250</td>
</tr>
<tr>
<td>Porous</td>
<td>775</td>
</tr>
<tr>
<td>Modified bituminous sealant primer</td>
<td>500</td>
</tr>
<tr>
<td>Other sealant primers</td>
<td>750</td>
</tr>
<tr>
<td>CPVC solvent cement</td>
<td>490</td>
</tr>
<tr>
<td>PVC solvent cement</td>
<td>510</td>
</tr>
</tbody>
</table>

**TABLE 13.6.2(1)**

<table>
<thead>
<tr>
<th>ADHESIVE</th>
<th>VOC LIMIT (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor carpet adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Carpet pad adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Outdoor carpet adhesives</td>
<td>150</td>
</tr>
<tr>
<td>Wood flooring adhesive</td>
<td>100</td>
</tr>
<tr>
<td>Rubber floor adhesives</td>
<td>60</td>
</tr>
<tr>
<td>Subfloor adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Ceramic tile adhesives</td>
<td>65</td>
</tr>
<tr>
<td>VCT and asphalt tile adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Dry wall and panel adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Cove base adhesives</td>
<td>50</td>
</tr>
<tr>
<td>Multipurpose construction adhesives</td>
<td>70</td>
</tr>
<tr>
<td>Structural glazing adhesives</td>
<td>100</td>
</tr>
<tr>
<td>Single-ply roof membrane adhesives</td>
<td>250</td>
</tr>
<tr>
<td>Architectural sealants</td>
<td>250</td>
</tr>
<tr>
<td>Architectural sealant primer</td>
<td></td>
</tr>
<tr>
<td>Nonporous</td>
<td>250</td>
</tr>
<tr>
<td>Porous</td>
<td>775</td>
</tr>
<tr>
<td>Modified bituminous sealant primer</td>
<td>500</td>
</tr>
<tr>
<td>Other sealant primers</td>
<td>750</td>
</tr>
<tr>
<td>CPVC solvent cement</td>
<td>490</td>
</tr>
<tr>
<td>PVC solvent cement</td>
<td>510</td>
</tr>
</tbody>
</table>
TABLE 13.6.2(2)
VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>VOC</th>
<th>LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual VOCs</td>
<td>$$\leq \frac{1}{2} \text{ CA chronic REL}$$ a</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>$$\leq 16.5 \text{ µg/m}^3$$ or $$\leq 13.5 \text{ ppb}$$ b, c</td>
</tr>
</tbody>
</table>

a. VOC limit less water and less exempt compounds in grams/liter.
b. For low-solid adhesives and sealants, the VOC limit is expressed in grams/liter of material as specified in Rule 1168. For all other adhesives and sealants, the VOC limits are expressed as grams of VOC per liter of adhesive or sealant less water and less exempt compounds as specified in Rule 1168.

c. Formaldehyde emission levels need not be reported for materials where formaldehyde is not added by the manufacturer of the material.

13.6.3 Architectural paints and coatings.
A minimum of 85 percent by weight or volume, of site-applied interior architectural coatings shall comply with VOC content limits in Table 13.6.3(1) or the alternate emissions limits in Table 13.6.3(2). The exempt compound content shall be determined by ASTM D3960.

Table 13.6.3(2) architectural coating alternate emissions standards compliance shall be determined utilizing test methodology incorporated by reference in the CDPH/EHLB/Standard Method V.1.1. The alternative emissions testing shall be performed by a laboratory that has the CDPH/EHLB/Standard Method V.1.1 test methodology in the scope of its ISO 17025 Accreditation.

TABLE 13.6.3(1)
VOC CONTENT LIMITS FOR ARCHITECTURAL COATINGS c, d, e

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Effective: January 1, 2010</th>
<th>Effective: January 1, 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LIMIT a</td>
<td>LIMIT a</td>
</tr>
<tr>
<td></td>
<td>g/l</td>
<td>g/l</td>
</tr>
<tr>
<td>Flat coatings</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td>Nonflat coatings</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>Nonflat – High-gloss coatings</td>
<td>150</td>
<td>—</td>
</tr>
<tr>
<td>Specialty coatings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum roof coatings</td>
<td>400</td>
<td>—</td>
</tr>
<tr>
<td>Basement specialty coatings</td>
<td>400</td>
<td>—</td>
</tr>
<tr>
<td>Bituminous roof coatings</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td>Bituminous roof primers</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Bond breakers</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Concrete curing compounds</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Concrete/masonry sealers</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>Driveway sealers</td>
<td>50</td>
<td>—</td>
</tr>
<tr>
<td>Dry fog coatings</td>
<td>150</td>
<td>—</td>
</tr>
<tr>
<td>Faux finishing coatings</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Fire-resistant coatings</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Floor coatings</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>Form-release compounds</td>
<td>250</td>
<td>—</td>
</tr>
<tr>
<td>Graphic arts coatings (Sign paints)</td>
<td>500</td>
<td>—</td>
</tr>
<tr>
<td>High-temperature coatings</td>
<td>420</td>
<td>—</td>
</tr>
<tr>
<td>Industrial maintenance coatings</td>
<td>250</td>
<td>—</td>
</tr>
<tr>
<td>Low solids coatings</td>
<td></td>
<td>120</td>
</tr>
<tr>
<td>Magnesite cement coatings</td>
<td></td>
<td>450</td>
</tr>
</tbody>
</table>

a. CDPH/EHLB/Standard Method V.1.1 Chronic Reference Exposure Level (CREL).
b. Effective January 1, 2012, limit became less than or equal to the CDPH/EHLB/Standard Method V.1.1 CREL ($$\leq 9 \text{ µg/m}^3$$ or $$\leq 7 \text{ ppb}$$).
c. Formaldehyde emission levels need not be reported for materials where formaldehyde is not added by the manufacturer of the material.
<table>
<thead>
<tr>
<th>Product Type</th>
<th>VOC Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastic texture coatings</td>
<td>100</td>
</tr>
<tr>
<td>Metallic pigmented coatings</td>
<td>500</td>
</tr>
<tr>
<td>Multi-color coatings</td>
<td>250</td>
</tr>
<tr>
<td>Pretreatment wash primers</td>
<td>420</td>
</tr>
<tr>
<td>Primers, sealers, and undercoaters</td>
<td>100</td>
</tr>
<tr>
<td>Reactive penetrating sealers</td>
<td>350</td>
</tr>
<tr>
<td>Recycled coatings</td>
<td>250</td>
</tr>
<tr>
<td>Roof coatings</td>
<td>50</td>
</tr>
<tr>
<td>Rust-preventative coatings</td>
<td>400</td>
</tr>
<tr>
<td>Shellacs, clear</td>
<td>730</td>
</tr>
<tr>
<td>Shellacs, opaque</td>
<td>550</td>
</tr>
<tr>
<td>Specialty primers, sealers, and undercoaters</td>
<td>350</td>
</tr>
<tr>
<td>Stains</td>
<td>250</td>
</tr>
<tr>
<td>Stone consolidants</td>
<td>450</td>
</tr>
<tr>
<td>Swimming pool coatings</td>
<td>340</td>
</tr>
<tr>
<td>Traffic marking coatings</td>
<td>100</td>
</tr>
<tr>
<td>Tub and tile refinish coatings</td>
<td>420</td>
</tr>
<tr>
<td>Waterproofing membranes</td>
<td>250</td>
</tr>
<tr>
<td>Wood coatings</td>
<td>275</td>
</tr>
<tr>
<td>Wood preservatives</td>
<td>350</td>
</tr>
<tr>
<td>Zinc-rich primers</td>
<td>340</td>
</tr>
</tbody>
</table>

a. Limits are expressed as VOC Regulatory (except as noted), thinned to the manufacturer’s maximum thinning recommendation, excluding any colorant added to tint bases.
b. Limit is expressed as VOC actual.
c. The specified limits remain in effect unless revised limits are listed in subsequent columns in the table.
d. Values in this table are derived from those specified by the California Air Resources Board Suggested Control Measure for Architectural Coatings, dated February 1, 2006.
e. Table 13.6.3(1) architectural coating regulatory category and VOC content compliance determination shall conform to the California Air Resources Board Suggested Control Measure for Architectural Coatings.

**TABLE 13.6.3(2)**
ARCHITECTURAL COATINGS VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>VOC</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>≤ ( \frac{1}{2} ) CA chronic REL(^a)</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>≤ 16.5 µg/m³ or ≤ 13.5 ppb(^b)</td>
</tr>
</tbody>
</table>

a. CA Chronic Reference Exposure Level (CREL).
b. Formaldehyde emission levels are not required for materials where formaldehyde is not added by the manufacturer of the material.

13.6.4 Flooring.

A minimum of 85 percent of the total area of flooring installed within the interior of the building shall comply with the requirements of Table 13.6.4(2). Where flooring with more than one distinct product layer is installed, emissions from each layer shall comply with these requirements. The test methodology used to determine compliance shall be from CDPH/EHLB/Standard Method V.1.1. The emissions testing shall be performed by a laboratory that has the CDPH/EHLB/Standard Method V.1.1 test methodology in the scope of its ISO 17025 Accreditation.

Where post-manufacture coatings or surface applications have not been applied, the flooring listed in Table 13.6.4(1) shall be deemed to comply with the requirements of Table 13.6.4(2).

**TABLE 13.6.4(1)**
FLOORING DEEMED TO COMPLY WITH VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>Material Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic and concrete tile</td>
</tr>
<tr>
<td>Organic-free, mineral-based</td>
</tr>
<tr>
<td>Clay pavers</td>
</tr>
<tr>
<td>Concrete pavers</td>
</tr>
<tr>
<td>Concrete</td>
</tr>
<tr>
<td>Metal</td>
</tr>
</tbody>
</table>

**TABLE 13.6.4(2)**
FLOORING VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>VOC</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>≤ ( \frac{1}{2} ) CA chronic REL(^a)</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>≤ 16.5 µg/m³ or ≤ 13.5 ppb(^b)</td>
</tr>
</tbody>
</table>
13.6.5 Acoustical ceiling tiles and wall systems.

A minimum of 85 percent of acoustical ceiling tiles and wall systems, by area, shall comply with the requirements of Table 13.6.5(2). Where ceiling and wall systems with more than one distinct product layer are installed, the emissions from each layer shall comply with these requirements. The test methodology used to determine compliance shall be from CDPH/EHLB/Standard Method V.1.1. The emissions testing shall be performed by a laboratory that has the CDPH/EHLB/Standard Method V.1.1 test methodology in the scope of its ISO 17025 Accreditation.

Where post-manufacture coatings or surface applications have not been applied, the ceiling or wall systems listed in Table 13.6.5(1) shall be deemed to comply with the requirements of Table 13.6.5(2).

### TABLE 13.6.5(1)
CEILING AND WALL SYSTEMS DEEMED TO COMPLY WITH VOC EMISSION LIMITS

| Ceramic and concrete tile | Organic-free, mineral-based | Gypsum plaster | Clay masonry | Concrete masonry | Concrete | Metal |
|---------------------------|----------------------------|---------------|-------------|------------------|---------|

### TABLE 13.6.5(2)
ACOUSTICAL CEILING TILES AND WALL SYSTEMS VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>VOC</th>
<th>LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>$\leq \frac{1}{2}$ CA chronic REL $^a$</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>$\leq 16.5 \mu g/m^3$ or $\leq 13.5$ ppb</td>
</tr>
</tbody>
</table>

13.6.6 Insulation.

A minimum of 85 percent of insulation shall comply with the requirements of Table 13.6.6(1) or Table 13.8.6(2). The test methodology used to determine compliance shall be from CDPH/EHLB/Standard Method V.1.1. The emissions testing shall be performed by a laboratory that has the CDPH/EHLB/Standard Method V.1.1 test methodology in the scope of its ISO 17025 Accreditation.

### TABLE 13.6.6(1)
INSULATION VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>VOC</th>
<th>LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>$\leq \frac{1}{2}$ CA chronic REL $^a$</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>$\leq 16.5 \mu g/m^3$ or $\leq 13.5$ ppb</td>
</tr>
</tbody>
</table>

### TABLE 13.6.6(2)
INSULATION MANUFACTURED WITHOUT FORMALDEHYDE VOC EMISSION LIMITS

<table>
<thead>
<tr>
<th>VOC</th>
<th>LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>$\leq \frac{1}{2}$ CA chronic REL $^a$</td>
</tr>
</tbody>
</table>

13.7 ACOUSTICS

13.7.1 Sound transmission and sound levels.

Where required by this Code, buildings and tenant spaces shall comply with the minimum sound transmission class and maximum sound level requirements of Clauses 13.7.2 through 13.7.5.2.

**Exception:** The following buildings and spaces need not comply with this clause:

1. Building or structures that have the interior environment open to the exterior environment.
2. Parking structures.
3. Concession stands and toilet facilities in Group A-4 and A-5 occupancies.

3. Spaces and occupancies that are accessory to the main occupancy.

13.7.2 Sound transmission.

Sound transmission classes established by laboratory measurements shall be determined in accordance with ASTM E413 based on measurements in accordance with ASTM E90. Sound transmission classes for concrete masonry and clay masonry assemblies shall be calculated in accordance with TMS 0302 or determined in accordance with ASTM E413 based on measurements in accordance with ASTM E90. Field measurements of completed construction, if conducted, shall be in accordance with ASTM E336 where conditions regarding room size and absorption required in ASTM E336 are met.

13.7.2.1 Interior sound transmission.

Wall and floor-ceiling assemblies that separate Group A and F occupancies from one another or from Group B, I, M or R occupancies shall have a sound transmission class (STC) of not less than 60 or an apparent sound transmission class (ASTC) of not less than 55 if the completed construction is field tested. Wall and floor-ceiling assemblies that separate Group B, I, M or R occupancies from one another shall have a sound transmission class (STC) of not less than 50 or an apparent sound transmission class (ASTC) of not less than 45 if the completed construction is field tested. Wall and floor-ceiling assemblies that separate Group R condominium occupancies from one another or from other Group B, I, M or R occupancies shall have a sound transmission class (STC) of not less than 55 or an apparent sound transmission class (ASTC) of not less than 50 if the completed construction is field tested. New laboratory tests for STC of an assembly are not required where the STC has been established by prior tests.

Exception: This clause shall not apply to wall and floor-ceiling assemblies enclosing:

1. Public entrances to tenants of covered and open mall buildings.

2. Concession stands and lavatories in Group A-4 and A-5 occupancies.

13.7.2.2 Mechanical and emergency generator equipment and systems.

Wall and floor-ceiling assemblies that separate a mechanical equipment room or space from the remainder of the building shall have a sound transmission class (STC) of not less than 50 or an apparent sound transmission class (ASTC) of not less than 45 if the completed construction is field tested. Wall and floor-ceiling assemblies that separate a generator equipment room or space from the remainder of the building shall have a sound transmission class (STC) of not less than 60 or an apparent sound transmission class (ASTC) of not less than 55 if the completed construction is field tested.

13.7.3 Sound levels.

The design and construction of mechanical and electrical generator systems and of walls and floor-ceilings separating such equipment from the outdoors or other building space shall achieve sound levels not greater than specified in Clauses 13.7.3.1 and 13.7.3.2 during the normal operation of mechanical equipment and generators. Electrical generators used only for emergencies are exempt from the limits on sound levels within the building and need only meet daytime limits for sound-reaching boundaries. Where necessary, wall and floor-ceiling assemblies with sound transmission class (STC) ratings greater than specified in Clause 13.7.2.2 shall be used to meet this requirement.

13.7.3.1 Sound of mechanical and electrical generator equipment outside of buildings.

Where mechanical equipment or electrical generators are located outside of the building envelope or their sound is exposed to the exterior environment, the sound reaching adjacent properties shall comply with all applicable ordinances and zoning performance standards. In the absence of an ordinance or zoning performance standard specifying sound limits at the boundary, or a law specifying different limits if limits are imposed, an adjacent property at the boundary shall not be subjected
to a sound level greater than indicated in Table 13.7.3.1 because of the operation of the equipment. When a generator is used for providing emergency power and periodic operational testing is done during the night-time period of Table 13.7.3.1, the sound of a generator during the night-time period shall meet the daytime limits.

### TABLE 13.7.3.1
**MAXIMUM PERMISSIBLE OUTDOOR A-WEIGHTED SOUND LEVELS**

<table>
<thead>
<tr>
<th>INITIATING PROPERTY</th>
<th>ADJACENT PROPERTY</th>
<th>MAXIMUM A-WEIGHTED SOUND LEVELS (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>7:00 AM to 10:00 PM</strong></td>
</tr>
<tr>
<td>All, except factory, industrial or storage</td>
<td>All, except factory, industrial or storage</td>
<td>65</td>
</tr>
<tr>
<td>Factory, industrial or storage</td>
<td>Factory, industrial or storage</td>
<td>75</td>
</tr>
</tbody>
</table>

### 13.7.3.2 Sound of HVAC and mechanical systems within buildings.

Sound levels within rooms generated by HVAC and mechanical systems within the building, excluding emergency generators, for all modes of operation shall not exceed the limits shown in Table 13.7.3.2.

### TABLE 13.7.3.2
**MAXIMUM PERMISSIBLE INDOOR BACKGROUND SOUND IN ROOMS**

<table>
<thead>
<tr>
<th>OCCUPANCY TYPE</th>
<th>ROOM</th>
<th>NOISE CRITERIA (NC) LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly A-1</td>
<td>Symphony, concert, recital halls</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Motion picture theaters</td>
<td>40</td>
</tr>
<tr>
<td>Assembly A-3</td>
<td>Places of religious worship, lecture halls not part of educational facilities</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Art gallery, exhibit hall, funeral parlor, libraries, and museums</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Courtroom</td>
<td>35 (See Educational)</td>
</tr>
<tr>
<td></td>
<td>Educational occupancies above 12th grade</td>
<td></td>
</tr>
<tr>
<td>Assembly A-4</td>
<td>Gymnasiums, natatoriums and arenas with seating areas</td>
<td>45</td>
</tr>
<tr>
<td>Business B</td>
<td>Office—enclosed greater than 300 square feet</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Office—enclosed less than or equal to 300 square feet</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Office—open plan</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Corridors and lobbies</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Conference rooms</td>
<td>35 (See Educational)</td>
</tr>
<tr>
<td></td>
<td>Educational occupancies above 12th grade</td>
<td></td>
</tr>
<tr>
<td>Educational E</td>
<td>Core learning lecture and classrooms that are less than or equal to 20,000 cubic feet in volume</td>
<td>ANSI/ASA S12.60-2010/Part 1 or ANSI/ASA S12.60-2009/Part 2</td>
</tr>
<tr>
<td></td>
<td>Core learning lecture and classrooms that are greater than 20,000 cubic feet in volume</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open plan classrooms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Administrative offices and rooms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Music teaching studios</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Music practice rooms</td>
<td></td>
</tr>
<tr>
<td>Institutional I-2</td>
<td>All areas</td>
<td>2010 FGI-ASHE Guidelines for Design and Construction of Healthcare Facilities</td>
</tr>
<tr>
<td>Residential R-1 and R-2</td>
<td>Meeting rooms</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Corridors and lobbies</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Service areas</td>
<td>45</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.093 m², 1 cubic foot = 28.31 L.
13.7.4 Structure-borne sounds.
Floor and ceiling assemblies separating sleeping units or dwelling units from public or service areas within the structure in occupations classified as Group A1, A2, A3, B, E, I, M or R, or sleeping units or dwelling units from adjacent sleeping units or dwelling units in Group R occupancies, shall have an impact insulation classification (IIC) rating of not less than 50 where laboratory tested, and 45 where field tested, when tested in accordance with ASTM E492. New laboratory tests for impact insulation class (IIC) of an assembly are not required where the IIC has been established by prior tests.

13.7.5 Commissioning for sound levels.
An approved agency, employed by the owner or the owner’s authorized agent, shall furnish report(s) of test findings indicating that the sound level results are in compliance with this clause and the construction documents. Discrepancies shall be brought to the attention of the contractor for correction. If they are not corrected, the discrepancies shall be brought to the attention of the design professional and Code official prior to the completion of that work. A final testing report documenting required testing and corrections of any discrepancies noted in prior tests shall be submitted at a point in time agreed upon by the owner, or owner’s authorized agent, design professional, and the Code official for purposes of demonstrating compliance.

Exception: Group I-2 occupancies that comply with the 2010 FGI-ASHE Guidelines for Design and Construction of Healthcare Facilities are not required to comply with this clause where furnishing a report of test findings of the sound transmission results.

13.7.5.1 Testing for mechanical and electrical generator equipment outside of buildings.
Commissioning shall be conducted in accordance with this Code to demonstrate compliance with the requirements of Clause 13.7.3.1. Testing shall be conducted following the complete installation of the equipment or generators, the installation of sound reduction barriers, and balancing and operation of the equipment or generators. Testing shall be at locations representing the four cardinal directions from the face of the project building. Such testing shall demonstrate that the equipment is capable of compliance with the night-time limits under normal night-time operating conditions, and if higher sound levels are possible during the daytime, compliance with the daytime limits shall also be demonstrated.

13.7.5.2 Testing for building system background noise.
Commissioning shall be conducted in accordance with this Code to demonstrate compliance with the requirements of Clause 13.7.3.2. Testing shall be executed within not less than 50 percent of the total number of rooms contained in a building or structure of the types listed in Table 13.7.3.2 for the given occupancy in accordance with this Code. Testing shall occur following the complete installation of the equipment and systems, the installation of any sound reduction barriers, and balancing and operation of the equipment and systems.

13.8 DAYLIGHTING

13.8.1 General.
Fenestration shall be provided in building roofs and walls in accordance with Clauses 13.8.2 and 13.8.3. Interior spaces shall be planned to benefit from exposure to the natural light offered by the fenestration in accordance with this clause.

13.8.1.1 Fenestration obstructions.
Advertisements or displays affixed or applied to a fenestration, or supported by the building, shall not reduce daylighting below the levels prescribed herein.

Exception: The ground floor and the storey immediately above the ground floor.

13.8.2 Applicability.
Daylighting of building spaces in accordance with Clause 13.8.3 shall be required for the following occupancies:

1. A Group A-3 occupancy where the specific use of the room or space is for reading areas in libraries, waiting areas in transportation terminals, exhibition halls, convention centers, gymnasiums, and indoor athletic areas.

2. A Group B occupancy where the specific use of the room or space is for
laboratories for testing and research, post offices, print shops, offices, educational facilities for students above the 12th grade and training and skill development not within a school or academic program.

3. Group E, F and S occupancies.

4. Those portions of Group M occupancies located directly underneath a roof, where the net floor area of the entire occupancy is 232 m$^2$ (2,500 square feet) or greater.

**Exception:** Daylighting in Groups A-3, B, E, F, M and S occupancies is not required for the following:

1. Building spaces where darkness is required for the primary use of the space, including, but not limited to, light-sensitive material handling and darkrooms.

2. Building spaces that are required to be cooled below 50°F (10°C).

3. Unconditioned buildings that are equipped with exterior doors that, when opened, provide equivalent daylighting.

4. Existing buildings undergoing an alteration, repair, movement, or change of occupancy.

### 13.8.3 Daylit area of building spaces.

In buildings not greater than two stories above grade, not less than 50 percent of the net floor area shall be located within a daylit area. In buildings three or more stories above grade, not less than 25 percent of the net floor area shall be located within a daylit area. Buildings required to have more than 2,323 m$^2$ (25,000 square feet) of daylit area shall comply with Clause 13.8.3.2. All other buildings shall comply with either Clause 13.8.3.1 or Clause 13.8.3.2.

**Exception:** For buildings not less than three stories above grade with obstructed exterior walls or shaded roofs, the required daylit area shall be modified in accordance with Equation 13-1.

\[
\text{Required daylit area} \geq 25\% \times TDP
\]

The total daylight potential (TDP) is a weighted average of the individual daylight potentials for each floor:

\[
TDP = \Sigma (DP_{1} \div FA_{1}/TF) + (DP_{2} \div FA_{2}/TF) + ...
\]

For floors with roof area immediately above:

\[
DP_{1,2} \ldots = 1 - [(OW_{1}/TW_{1}) \times (OR_{1}/TR_{1})]
\]

For floors without roof area immediately above:

\[
DP_{1,2} \ldots = 1 - (OW_{1}/TW_{1})
\]

Where:

\[
OW_{1,2} = \text{The length of obstructed exterior wall for each floor.}
\]

\[
OR_{1,2} = \text{The roof area immediately above each floor that is shaded during the peak sun angle on the summer solstice by permanent features of the building, or by permanent features of adjacent buildings.}
\]

\[
TR_{1,2} = \text{The total roof area immediately above each floor.}
\]

\[
FA_{1,2} = \text{The total floor area of each floor.}
\]

\[
TF = \text{The total building floor area.}
\]

### 13.8.3.3 Daylight prescriptive requirements.

Daylit areas shall comply with the following:

1. Each daylit area shall be located within a toplight or sidelight daylight zone, determined in accordance with this Code.

(Equation 13-1)
2. The effective aperture of fenestration for the daylight zone, determined in accordance with Equation 13-2, shall comply with Table 13.8.3.1.

3. Overlapping daylight zones shall be counted only once.

\[ EA = \frac{(AF \times VT)}{DA} \]  
(Equation 13-2)

### Table 13.8.3.1

<table>
<thead>
<tr>
<th>SKY TYPE</th>
<th>MINIMUM EFFECTIVE APERTURE (percentage)</th>
<th>Sidelighting from fenestration in a wall</th>
<th>Sidelighting from rooftop monitor</th>
<th>Toplighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>12.5</td>
<td>5.0</td>
<td>1.0</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>15.0</td>
<td>6.0</td>
<td>1.2</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>20.0</td>
<td>8.0</td>
<td>2.2</td>
</tr>
</tbody>
</table>

a. Sky Type A – more than 75 percent mean sunshine, in accordance with the NOAA Annual Mean Sunshine Percentage Table.
b. Sky Type B – 45 percent to 75 percent mean sunshine, in accordance with the NOAA Annual Mean Sunshine Percentage Table.
c. Sky Type C – less than 45 percent mean sunshine, in accordance with the NOAA Annual Mean Sunshine Percentage Table.

### 13.8.3.2 Daylight performance path.

Each daylit area shall comply with the requirements of either Clause 13.8.3.2.1 or 13.8.3.2.2. Daylight analysis shall be conducted in accordance with Clause 13.8.3.2.3.

#### 13.8.3.2.1 Morning illumination.

Not less than 28 footcandles (300 lux) and not more than 418 footcandles (4500 lux) of natural light shall be available at a height of 750 mm (30 inches) above the floor 3 hours before the peak solar angle on the spring equinox.

#### 13.8.3.2.2 Afternoon illumination.

Not less than 28 footcandles (300 lux) and not more than 418 footcandles (4500 lux) of natural light shall be available at a height of 750 mm (30 inches) above the floor 3 hours after the peak solar angle on the spring equinox.

#### 13.8.3.2.3 Daylight analysis.

A daylight analysis shall be performed that complies with the following:

1. Sky conditions shall be assumed to be clear.
2. Address the effects of exterior shading devices, buildings, structures, and geological formations on the fenestration.
6. Calculation points shall be spaced not more than 1 m (39.4 inches) by 1 m (39.4 inches). The calculation grid shall start within 508 mm (20 inches) of each wall or partition.

7. Where details about the window framing, mullions, wall thickness and well depth cannot be included in the model, the visible transmittance of all fenestration shall be reduced by 20 percent.

13.8.4 Sky types.
Sky types as described in Clause 13.8.4.1 or 13.8.4.2 shall be used in determining the applicable effective aperture in Table 13.8.3.1.

13.8.4.1 United States sky types.
All states, counties, and territories shall be sky type B, except as named herein. The states and counties in sky type A shall be: all of Arizona; in Nevada the counties of Churchill, Lincoln, Nye, Washoe, and counties south; in New Mexico the counties of Lincoln, Otero, Sandoval, San Juan, Santa Fe, Torrance and counties south; in Texas the counties of Hudspeth, El Paso, and Jeff Davis; in Utah the counties of Iron, Kane, and Washington; and in California all counties except Del Norte, Siskiyou, Modoc, Humboldt, Trinity, and Mendocino. Alaska shall be sky type C.

13.8.4.2 International sky types.
All international locations shall be sky type B, except as follows: locations with an annual average of more than 75 percent sunshine during daytime hours shall be sky type A, and locations with an annual average of less than 45 percent sunshine during daytime hours shall be sky type C.

13.9 VENTILATION

13.9.1 General.
Buildings shall be provided with natural ventilation in accordance with Clause 13.9.5, or mechanical ventilation in accordance with this Code.

Where the air infiltration rate in a dwelling unit is less than 5 air changes per hour where tested with a blower door at a pressure 0.2 inch w.c. (50 Pa) in accordance with this Code, the dwelling unit shall be ventilated by mechanical means in accordance with this Code. Ambulatory care facilities and Group I-2 occupancies shall be ventilated by mechanical means in accordance with this Code.

13.9.2 Roof ventilation.
Roof assemblies shall be ventilated in accordance with this clause or shall comply with Clause this Code.

13.9.2.1 Ventilated attics and rafter spaces.
Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof framing members shall have cross ventilation for each separate space by ventilation openings protected against the entrance of rain and snow. Blocking and bridging shall be arranged so as not to interfere with the movement of air. An airspace of not less than 25 mm (1 inch) shall be provided between the insulation and the roof sheathing. The net free ventilating area shall be not less than \( \frac{1}{150} \) of the area of the space ventilated.

Ventilators shall be installed in accordance with manufacturer's installation instructions.

Exception: The net free cross-ventilation area shall be permitted to be reduced to \( \frac{1}{300} \) provided both of the following conditions are met:

1. In Climate Zones 6, 7 and 8, a Class I or II vapour retarder is installed on the warm-in-winter side of the ceiling.

2. At least 40 percent and not more than 50 percent of the required venting area is provided by ventilators located in the upper portion of the attic or rafter space. Upper ventilators shall be located not more than 914 mm (3 feet) below the ridge or highest point of the space, measured vertically, with the balance of the ventilation provided by eave or cornice vents. Where the location of wall or roof...
framing members conflicts with the installation of upper ventilators, installation more than 914 mm (3 feet) below the ridge or highest point of the space shall be permitted.

13.9.2.2 Openings into attic.

Exterior openings into the attic space of any building intended for human occupancy shall be protected to prevent the entry of birds, squirrels, rodents, snakes and other similar creatures. Openings for ventilation having a least dimension of not less than 1.6 mm (\(\frac{1}{16}\) inch) and not more than 6.4 mm (\(\frac{1}{4}\) inch) shall be permitted. Openings for ventilation having a least dimension larger than 6.4 mm (\(\frac{1}{4}\) inch) shall be provided with corrosion-resistant wire cloth screening, hardware cloth, perforated vinyl or similar material with openings having a least dimension of not less than 1.6 mm (\(\frac{1}{16}\) inch) and not more than 6.4 mm (\(\frac{1}{4}\) inch).

Where combustion air is obtained from an attic area, it shall be in accordance with Part 7 of the International Mechanical Code.

13.9.3 Unvented attic and unvented enclosed rafter assemblies.

Unvented attics and unvented enclosed roof framing assemblies created by ceilings applied directly to the underside of the roof framing members/rafters and the structural roof sheathing at the top of the roof framing members shall be permitted where all of the following conditions are met:

1. The unvented attic space is completely within the building thermal envelope.

2. No interior Class I vapour retarders are installed on the ceiling side (attic floor) of the unvented attic assembly or on the ceiling side of the unvented enclosed roof framing assembly.

3. Where wood shingles or shakes are used, not less than a 6.4 mm (\(\frac{1}{4}\)-inch) vented airspace separates the shingles or shakes and the roofing underlayment above the structural sheathing.

4. In Climate Zones 5, 6, 7 and 8, any air-impermeable insulation shall be a Class II vapour retarder or shall have a Class II vapour retarder coating or covering in direct contact with the underside of the insulation.

5. Insulation shall be located in accordance with the following:

5.1. Item 5.1.1, 5.1.2, 5.1.3 or 5.1.4 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.

5.1.1. Where only air-impermeable insulation is provided, it shall be applied in direct contact with the underside of the structural roof sheathing.

5.1.2. Where air-permeable insulation is provided inside the building thermal envelope, it shall be installed in accordance with Item 5.1.1. In addition to the air-permeable insulation installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing in accordance with the R-values in Table 1202.3 for condensation control.

5.1.3. Where both air-impermeable and air-permeable insulation are provided, the air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing in accordance with Item 5.1.1 and shall be in accordance with the R-values in Table 13.9.3 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.
5.1.4. Alternatively, sufficient rigid board or sheet insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.

5.2. Where preformed insulation board is used as the air-impermeable insulation layer, it shall be sealed at the perimeter of each individual sheet interior surface to form a continuous layer.

Exceptions:

1. Clause 13.9.3 does not apply to special use structures or enclosures such as swimming pool enclosures, data processing centers, hospitals or art galleries.

2. Clause 13.9.3 does not apply to enclosures in Climate Zones 5 through 8 that are humidified beyond 35 percent during the three coldest months.

### TABLE 13.9.3
INSULATION FOR CONDENSATION CONTROL

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>MINIMUM R-VALUE OF AIR-IMPERMEABLE INSULATION a</th>
</tr>
</thead>
<tbody>
<tr>
<td>2B and 3B tile roof only</td>
<td>0 (none required)</td>
</tr>
<tr>
<td>1, 2A, 2B, 3A, 3B, 3C</td>
<td>R-5</td>
</tr>
<tr>
<td>4C</td>
<td>R-10</td>
</tr>
<tr>
<td>4A, 4B</td>
<td>R-15</td>
</tr>
<tr>
<td>5</td>
<td>R-20</td>
</tr>
<tr>
<td>6</td>
<td>R-25</td>
</tr>
<tr>
<td>7</td>
<td>R-30</td>
</tr>
<tr>
<td>8</td>
<td>R-35</td>
</tr>
</tbody>
</table>

a. Contributes to, but does not supersede, thermal resistance requirements for attic and roof assemblies in Clause C402.2.1 of the International Energy Conservation Code.

13.9.4 Under-floor ventilation.
The space between the bottom of the floor joists and the earth under any building except spaces occupied by basements or cellars shall be provided with ventilation in accordance with Clause 13.9.4.1, 13.9.4.2 or 13.9.4.3.

13.9.4.1 Ventilation openings.
Ventilation openings through foundation walls shall be provided. The openings shall be placed so as to provide cross ventilation of the under-floor space. The net area of ventilation openings shall be in accordance with Clause 13.9.4.1.1 or 13.9.4.1.2. Ventilation openings shall be covered for their height and width with any of the following materials, provided that the least dimension of the covering shall be not greater than 6.4 mm (1/4 inch):

1. Perforated sheet metal plates not less than 1.8 mm (0.070 inch) thick.
2. Expanded sheet metal plates not less than 1.2 mm (0.047 inch) thick.
3. Cast-iron grilles or gratings.
4. Extruded load-bearing vents.
5. Hardware cloth of 0.89 mm (0.035-inch) wire or heavier.
6. Corrosion-resistant wire mesh, with the least dimension not greater than 3.2 mm (1/8 inch).
7. Operable louvres, where ventilation is provided in accordance with Clause 13.9.4.1.2.

13.9.4.1.1 Ventilation area for crawl spaces with open earth floors.
The net area of ventilation openings for crawl spaces with uncovered earth floors shall be not
13.9.4.1.2 Ventilation area for crawl spaces with covered floors.

The net area of ventilation openings for crawl spaces with the ground surface covered with a Class I vapour retarder shall be not less than $0.67 \ m^2$ for each $1000 \ m^2$ (1 square foot for each 1,500 square feet) of crawl space area.

13.9.4.2 Ventilation in cold climates.

In extremely cold climates, where a ventilation opening will cause a detrimental loss of energy, ventilation openings to the interior of the structure shall be provided.

13.9.4.3 Mechanical ventilation.

Mechanical ventilation shall be provided to crawl spaces where the ground surface is covered with a Class I vapour retarder. Ventilation shall be in accordance with Clause 13.9.4.3.1 or 13.9.4.3.2.

13.9.4.3.1 Continuous mechanical ventilation.

Continuously operated mechanical ventilation shall be provided at a rate of 1.0 cubic foot per minute (cfm) for each 50 square feet (1.02 L/s for each 10 m$^2$) of crawl space ground surface area and the ground surface shall be covered with a Class I vapour retarder.

13.9.4.3.2 Conditioned space.

The crawl space shall be conditioned in accordance with the International Mechanical Code and the walls of the crawl space shall be insulated in accordance with the International Energy Conservation Code.

13.9.4.4 Flood hazard areas.

For buildings in flood hazard areas as established in this Code, the openings for under-floor ventilation shall be deemed as meeting the flood opening requirements of the Relevant Flood Resistant Design and Construction Code provided that the ventilation openings are designed and installed in accordance with the Relevant Flood Resistant Design and Construction Code.

13.9.5 Natural ventilation.

Natural ventilation of an occupied space shall be through windows, doors, louvers or other openings to the outdoors. The operating mechanism for such openings shall be provided with ready access so that the openings are readily controllable by the building occupants.

13.9.5.1 Ventilation area required.

The openable area of the openings to the outdoors shall be not less than 4 percent of the floor area being ventilated.

13.9.5.1.1 Adjoining spaces.

Where rooms and spaces without openings to the outdoors are ventilated through an adjoining room, the opening to the adjoining room shall be unobstructed and shall have an area of not less than 8 percent of the floor area of the interior room or space, but not less than $2.3 \ m^2$ (25 square feet). The openable area of the openings to the outdoors shall be based on the total floor area being ventilated.

Exception: Exterior openings required for ventilation shall be allowed to open into a sunroom with thermal isolation or a patio cover provided that the openable area between the sunroom addition or patio cover and the interior room shall have an area of not less than 8 percent of the floor area of the interior room or space, but not less than $1.86 \ m^2$ (20 square feet). The openable area of the openings to the outdoors shall be based on the total floor area being ventilated.

13.9.5.1.2 Openings below grade.

Where openings below grade provide required natural ventilation, the outside horizontal clear space measured perpendicular to the opening shall be one and one-half times the depth of the opening. The depth of the opening shall be measured from the average adjoining ground level to the bottom of the opening.

13.9.5.2 Contaminants exhausted.

Contaminant sources in naturally ventilated spaces shall be removed in accordance with the Ghana Fire Code.

13.9.5.2.1 Bathrooms.

Rooms containing bathtubs, showers, spas and
similar bathing fixtures shall be mechanically ventilated in accordance with this Code.

13.9.5.3 Openings on yards or courts.
Where natural ventilation is to be provided by openings onto yards or courts, such yards or courts shall comply with Clause 13.12.

13.9.6 Other ventilation and exhaust systems.
Ventilation and exhaust systems for occupancies and operations involving flammable or combustible hazards or other contaminant sources as covered in the Ghana Fire Code shall be provided as required by both Codes.

13.10 TEMPERATURE CONTROL

13.10.1 Equipment and systems.
Interior spaces intended for human occupancy shall be provided with active or passive space heating systems capable of maintaining an indoor temperature of not less than 68°F (20°C) at a point 914 mm (3 feet) above the floor on the design heating day.

Exceptions: Space heating systems are not required for:

1. Interior spaces where the primary purpose of the space is not associated with human comfort.
2. Group F, H, S or U occupancies.

13.11 LIGHTING

13.11.1 General.
Every space intended for human occupancy shall be provided with natural light by means of exterior glazed openings in accordance with Clause 13.11.2 or shall be provided with artificial light in accordance with Clause 13.11.3. Exterior glazed openings shall open directly onto a public way or onto a yard or court in accordance with Clause 13.12.

13.11.2 Natural light.
The minimum net glazed area shall be not less than 8 percent of the floor area of the room served.

13.11.2.1 Adjoining spaces.
For the purpose of natural lighting, any room is permitted to be considered as a portion of an adjoining room where one-half of the area of the common wall is open and unobstructed and provides an opening of not less than one-tenth of the floor area of the interior room or 2.32 m² (25 square feet), whichever is greater.

Exception: Openings required for natural light shall be permitted to open into a sunroom with thermal isolation or a patio cover where the common wall provides a glazed area of not less than one-tenth of the floor area of the interior room or 1.86 m² (20 square feet), whichever is greater.

13.11.2.2 Exterior openings.
Exterior openings required by Clause 13.11.2 for natural light shall open directly onto a public way, yard or court, as set forth in Clause 13.12.

Exceptions:

1. Required exterior openings are permitted to open into a roofed porch where the porch meets all of the following criteria:
   1.1. Abuts a public way, yard or court.
   1.2. Has a ceiling height of not less than 2134 mm (7 feet).
   1.3. Has a longer side at least 65 percent open and unobstructed.

2. Skylights are not required to open directly onto a public way, yard or court.

13.11.3 Artificial light.
Artificial light shall be provided that is adequate to provide an average illumination of 10 footcandles (107 lux) over the area of the room at a height of 762 mm (30 inches) above the floor level.

13.11.4 Stairway Illumination.
Stairways within dwelling units and exterior stairways serving a dwelling unit shall have an illumination level on tread runs of not less than 1 footcandle (11 lux). Stairways in other occupancies shall be governed by Part 11.
13.11.4.1 Controls.
The control for activation of the required stairway lighting shall be in accordance with Ghana Wiring Code.

13.11.5 Emergency egress lighting.
The means of escape shall be illuminated in accordance with Clause 11.8.1.

13.12 YARDS OR COURTS

13.12.1 General.
This clause shall apply to yards and courts adjacent to exterior openings that provide natural light or ventilation. Such yards and courts shall be on the same plot as the building.

13.12.2 Yards.
Yards shall be not less than 914 mm (3 feet) in width for buildings two stories or less above grade plane. For buildings more than two stories above grade plane, the minimum width of the yard shall be increased at the rate of 305 mm (1 foot) for each additional storey. For buildings exceeding 14 stories above grade plane, the required width of the yard shall be computed on the basis of 14 stories above grade plane.

13.12.3 Courts.
Courts shall be not less than 914 mm (3 feet) in width. Courts having windows opening on opposite sides shall be not less than 6 feet (1829 mm) in width. Courts shall be not less than 3048 mm (10 feet) in length unless bounded on one end by a public way or yard. For buildings more than two stories above grade plane, the court shall be increased 305 mm (1 foot) in width and 610 mm (2 feet) in length for each additional storey. For buildings exceeding 14 stories above grade plane, the required dimensions shall be computed on the basis of 14 stories above grade plane.

13.12.3.1 Court access.
Access shall be provided to the bottom of courts for cleaning purposes.

13.12.3.2 Air intake.
Courts more than two stories in height shall be provided with a horizontal air intake at the bottom not less than 0.93 m² (10 square feet) in area and leading to the exterior of the building unless abutting a yard or public way.

13.12.3.3 Court drainage.
The bottom of every court shall be properly graded and drained to a public sewer or other approved disposal system complying with this Code.

13.13 SOUND TRANSMISSION

13.13.1 Scope.
This clause shall apply to common interior walls, partitions and floor/ceiling assemblies between adjacent dwelling units and sleeping units or between dwelling units and sleeping units and adjacent public areas such as halls, corridors, stairways or service areas.

13.13.2 Airborne sound.
Walls, partitions and floor-ceiling assemblies separating dwelling units and sleeping units from each other or from public or service areas shall have a sound transmission class of not less than 50, or not less than 45 if field tested, for airborne noise where tested in accordance with ASTM E90. Alternatively, the sound transmission class of walls, partitions and floor-ceiling assemblies shall be established by engineering analysis based on a comparison of walls, partitions and floor-ceiling assemblies having sound transmission class ratings as determined by the test procedures set forth in ASTM E90. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings. This requirement shall not apply to entrance doors; however, such doors shall be tight fitting to the frame and sill.

13.13.2.1 Masonry.
The sound transmission class of concrete masonry and clay masonry assemblies shall be calculated in accordance with TMS 0302 or determined through testing in accordance with ASTM E90.

13.13.3 Structure-borne sound.
Floor-ceiling assemblies between dwelling units...
and sleeping units or between a dwelling unit or sleeping unit and a public or service area within
the structure shall have an impact insulation
class rating of not less than 50, or not less than
45 if field tested, where tested in accordance
with ASTM E492. Alternatively, the impact
insulation class of floor-ceiling assemblies shall
be established by engineering analysis based
on a comparison of floor-ceiling assemblies
having impact insulation class ratings as
determined by the test procedures in ASTM
E492.

13.14 INTERIOR SPACE DIMENSIONS

Habitable spaces, other than a kitchen, shall be
not less than 2134 mm (7 feet) in any plan
dimension. Kitchens shall have a clear
passageway of not less than 914 mm (3 feet)
between counter fronts and appliances or
counter fronts and walls.

Occupiable spaces, habitable spaces and
corridors shall have a ceiling height of not less
than 7 feet 6 inches (2286 mm) above the
finished floor. Bathrooms, toilet rooms,
kitchens, storage rooms and laundry rooms
shall have a ceiling height of not less than 2134
mm (7 feet) above the finished floor.

Exceptions:

1. In one- and two-family dwellings,
beams or girders spaced not less
than 1219 mm (4 feet) on center
shall be permitted to project not
more than 152 mm (6 inches)
below the required ceiling height.

2. If any room in a building has a
sloped ceiling, the prescribed
ceiling height for the room is
required in one-half the area
thereof. Any portion of the room
measuring less than 1524 mm (5
feet) from the finished floor to the
ceiling shall not be included in any
computation of the minimum area
thereof.

3. The height of mezzanines and
spaces below mezzanines shall be
in accordance with Clause 6.8.2.

4. Corridors contained within a
dwelling unit or sleeping unit in a
Group R occupancy shall have a
ceiling height of not less than 2134
mm (7 feet) above the finished
floor.

13.14.2.1 Furred ceiling.
Any room with a furred ceiling shall be required
to have the minimum ceiling height in two-thirds
of the area thereof, but in no case shall the
height of the furred ceiling be less than 2134
mm (7 feet).

13.14.3 Room area.
Every dwelling unit shall have not less than one
room that shall have not less than 11.2 m$^2$ (120
square feet) of net floor area. Other habitable
rooms shall have a net floor area of not less
than 6.5 m$^2$ (70 square feet).

Exception: Kitchens are not required to be of a
minimum floor area.

13.14.4 Efficiency dwelling units.
An efficiency living unit shall conform to the
requirements of the Code except as modified
herein:

1. The unit shall have a living room of not
less than 20.4 m$^2$ (220 square feet) of
floor area. An additional 9.3 m$^2$ (100
square feet) of floor area shall be
provided for each occupant of such unit
in excess of two.

2. The unit shall be provided with a
separate closet.

3. The unit shall be provided with a
kitchen sink, cooking appliance and
refrigeration facilities, each having a
clear working space of not less than
762 mm (30 inches) in front. Light and
ventilation conforming to this Code
shall be provided.

5. The unit shall be provided with a
separate bathroom containing a water
closet, lavatory and bathtub or
shower.
13.15 ACCESS TO UNOCCUPIED SPACES

13.15.1 Crawl spaces.
Crawl spaces shall be provided with not less than one access opening that shall be not less than 457 mm by 610 mm (18 inches by 24 inches).

13.15.2 Attic spaces.
An opening not less than 559 mm by 762 mm (20 inches by 30 inches) shall be provided to any attic area having a clear height of over 762 mm (30 inches). Clear headroom of not less than 762 mm (30 inches) shall be provided in the attic space at or above the access opening.

13.15.3 Mechanical appliances.
Access to mechanical appliances installed in under-floor areas, in attic spaces and on roofs or elevated structures shall be in accordance with this Code.

13.16 TOILET AND BATHROOM REQUIREMENTS

13.16.1 Required fixtures.
The number and type of plumbing fixtures provided in any occupancy shall comply with Part 30.

13.16.2 Finish materials.
Walls, floors and partitions in toilet and bathrooms shall comply with Clauses 13.16.2.1 through 13.16.2.4.

13.16.2.1 Floors and wall bases.
In other than dwelling units, toilet, bathing and shower room floor finish materials shall have a smooth, hard, nonabsorbent surface. The interclauses of such floors with walls shall have a smooth, hard, nonabsorbent vertical base that extends upward onto the walls not less than 102 mm (4 inches).

13.16.2.2 Walls and partitions.
Walls and partitions within 610 mm (2 feet) of service sinks, urinals and water closets shall have a smooth, hard, nonabsorbent surface, to a height of not less than 1219 mm (4 feet) above the floor, and except for structural elements, the materials used in such walls shall be of a type that is not adversely affected by moisture.

Exception: This clause does not apply to the following buildings and spaces:

1. Dwelling units and sleeping units.
2. Toilet rooms that are not accessible to the public and that have not more than one water closet.

Accessories such as grab bars, towel bars, paper dispensers and soap dishes, provided on or within walls, shall be installed and sealed to protect structural elements from moisture.

13.16.2.3 Showers.
Shower compartments and walls above bathtubs with installed shower heads shall be finished with a smooth, nonabsorbent surface to a height not less than 1829 mm (72 inches) above the drain inlet.

13.16.2.4 Waterproof joints.
Built-in tubs with showers shall have waterproof joints between the tub and adjacent wall.

13.16.3 Privacy.
Privacy at water closets and urinals shall be provided in accordance with Clauses 13.16.3.1 and 13.16.3.2.

13.16.3.1 Water closet compartment.
Each water closet utilized by the public or employees shall occupy a separate compartment with walls or partitions and a door enclosing the fixtures to ensure privacy.

Exceptions:

1. Water closet compartments shall not be required in a single-occupant toilet room with a lockable door.
2. Toilet rooms located in child day care facilities and containing two or more water closets shall be permitted to have one water closet without an enclosing compartment.
3. This provision is not applicable to toilet areas located within Group I-3 occupancy housing areas.
13.16.3.2 Urinal partitions.

Each urinal utilized by the public or employees shall occupy a separate area with walls or partitions to provide privacy. The walls or partitions shall begin at a height not more than 305 mm (12 inches) from and extend not less than 1524 mm (60 inches) above the finished floor surface. The walls or partitions shall extend from the wall surface at each side of the urinal not less than 457 mm (18 inches) or to a point not less than 152 mm (6 inches) beyond the outermost front lip of the urinal measured from the finished backwall surface, whichever is greater.

Exceptions:

1. Urinal partitions shall not be required in a single-occupant or family or assisted-use toilet room with a lockable door.

2. Toilet rooms located in child day care facilities and containing two or more urinals shall be permitted to have one urinal without partitions.
PART 14: ENERGY EFFICIENCY AND SUSTAINABILITY

14.1 SCOPE
This Part sets out requirements and recommendations for energy efficiency in respect of mechanical ventilation systems, refrigeration equipment, hot water systems and lighting systems. The lighting system shall be designed and constructed in accordance with Clause 37.5 of this Code.

14.1.2 Performance Requirements
Services and equipment in buildings shall be as energy efficient as practicable and facilitate the conservation of energy.

Note: Requirements and recommendations for thermal insulation are specified in Clause 14.4.5.

14.2 MECHANICAL VENTILATION SYSTEMS

14.2.1 General requirements
Air-conditioning by means of mechanical refrigeration shall be installed only where absolutely necessary for human comfort, the storage of temperature-sensitive materials, or the operation of temperature or humidity sensitive equipment or processes. Air-conditioners shall meet the minimum energy performance and labelling requirements prescribed by law.

NOTES

1 Spaces which require continuous air change to remove build-up of smoke, heat, dust or odours from cooking, manufacturing, office machines, etc. should not be air-conditioned but should be cooled via natural or forced ventilation without the use of mechanical refrigeration.

2 Toilet rooms or other naturally ventilated spaces should be located where possible on exterior walls of buildings, provided with natural or forced exhaust ventilation, and isolated from air-conditioned spaces by self-closing, tight fitting doors.

3 Air-conditioning should not be considered where natural air movement or forced ventilation will meet environmental needs. Natural ventilation through properly located and designed windows and wall openings, or the use of fans or other air-moving devices, should always be fully considered prior to the specification of air-conditioning equipment. Note that the energy costs for "fan alone" systems require about 1/10th of the energy of air-conditioning.

4 Air-conditioning should not be used in areas which are only transiently occupied, i.e. for continuous periods of less than ½ hour at a time, such as storage or records rooms, laboratories, dressing rooms and washrooms.

14.3 REFRIGERATION EQUIPMENT AND APPLIANCES

(a) Refrigeration equipment shall be sized to meet the maximum anticipated load condition and no more. Unused space in refrigerated equipment results in excessive energy use per unit of product stored.

(b) Refrigeration compressor/condenser units shall be located in a shaded, well ventilated location and protected from any nearby source of materials which would clog the condenser coils.

(c) Water cooled equipment shall be fitted with equipment which removes hardness from condenser water. The owner shall be advised as to the necessary maintenance of the water treatment system.

(d) Defrost times for equipment shall be adjusted on-site on the basis of operating experience rather than being based solely on manufacturer's recommendation.

Refrigeration Appliances shall meet the minimum energy performance and labelling requirements prescribed by law.

14.4 HOT WATER

14.4.1 Need for hot water systems
Domestic hot water should be installed only where necessary. Consideration should be
given to not installing water heating equipment except where required for reasons of health, safety, process requirements, or to meet domestic needs. Generally, hot water is required only in the following areas:

(a) **Hotels/Apartments:** All rooms, public toilets, staff toilets. Not required in beach toilets or showers or public restrooms except where used by food service staff.

(b) **Restaurants:** Staff and public toilets, kitchen

(c) **Office Buildings:** Hot water not required for toilets. Use instantaneous heaters at janitors sinks if warm wash water is required.

(d) **Commercial Buildings**
(i) **Without food heating:** Hot water not required. Instantaneous heater recommended if hot water installed.

(ii) **With food handling:** Instantaneous heater for up to 25 seats. Commercial storage-type heater for more than 25 seat capacity.

(e) **Industrial Buildings**
(i) **Food Processing:** Hot water not required except where desired or required by employees for personal clean-up.

(ii) **Solar heating**

(a) Solar hot water or heat recovery systems should be designed and storage capacity sized to accommodate any substantial hot water demands which occur outside the time that the sun is shining or during the time which heat recovery is possible.

(b) Storage should be sized such that the solar or heat recovery system is capable of providing at least 70% of the average daily hot water demand.

(c) Pumped circulation systems should be considered for all commercial solar water heating systems except for single family residential uses.

14.4.3 **Standby losses**

Self-contained storage-type water heaters shall have a standby loss not exceeding the equivalent of 43 Watts per square metre of surface area.

**Notes:**

1. Newly purchased tanks should be of the “Energy Saver” or “energy conserving” type provided by several manufacturers – having at least 65 mm of high density fiberglass or equivalent insulation which allows reduced standby losses. Alternatively, standard type storage heaters should be provided with an insulating shroud of the equivalent of at least 65mm of blanket-type
fiberglass insulation in addition to the standard tank insulation.

2. Storage tanks greater than 450 litres should have an overall shell thermal resistance (“R value”) of at least 1.76m² k/W.

14.4.5 Storage capacity

(a) Instantaneous (non-storage) type water heaters should be used whenever possible, especially where projected use is less than 150 litres/day and peak flows are less than 0.1 litres/sec.

(b) Storage water heaters using any fuel should not be used except where high short term demands exceed the capacity of the largest rapid-recovery (instantaneous) unit available.

(c) Storage temperature for hot water used for normal domestic purposes should not exceed 50°C or 120°F except where storage is undersized due to periodic extraordinary demand or where space is limited for storage tanks.

14.4.6 Circulating systems

(a) Pumped circulating systems shall be employed only where absolutely required, such as in hospitals or large apartment buildings occupied full-time with round-the-clock demands where the economy in terms of reduced water wastage from avoiding long runs waiting for hot water at the tap outweigh the heat losses from piping and pump electricity use resulting from continuous circulation.

(b) All buildings where consumption is merely for periodic and sporadic hand wash or cleanup should utilize instantaneous heaters or small storage tanks at each point of use, rather than a central hot water system.

(c) Temperature: Circulating temperature or the thermostat controlling hot water circulation pump should be set no higher than 50°C or 120°F for normal domestic purposes – except where special needs require higher temperatures. Storage tank temperature should not exceed 130°F.

(d) All circulating hot water piping or non-circulating systems with a demand profile which requires that water be maintained at elevated temperature more than an average 6 hours/day, year round, shall be insulated with at least 20 mm fiberglass insulation or equivalent. Domestic hot water supply piping shall meet the insulation requirements for pipe insulation specifies in this Code.

(e) Timers: Where circulating systems are installed, if usage is nil during a period averaging 10 or more hours per week, a time switch should be installed to automatically stop the circulating pump during that period.

(f) Combustion efficiency: Combustion devices installed to produce hot water for any purpose shall have a rated combustion efficiency of at least 80%.

Notes:

1 Newly installed combustion devices should be operated by the installer under conditions simulating those of actual operation and a combustion analysis, and the device adjusted to demonstrate the actual on-site steady-state efficiency of the equipment.

2 Atmospheric natural gas or L.P.G. burners shall be exempt from the combustion analysis requirement, however the installer should ensure that operating pressure and air settings are within the manufacturer’s recommended limits for local conditions.

14.5 LIGHTING AND ELECTRICAL APPLIANCES

For Energy Efficiency information relating to lighting and electrical appliances, refer to Parts 13 and 28 of this Code.
PART 15: EXTERIOR WALLS

User notes:
About this part: Part 15 addresses requirements for exterior walls of buildings. Minimum standards for wall covering materials, such as material performance and fire resistance, installation of wall coverings and the ability of the wall to provide weather protection are provided. This part also contains limitations on the areas and heights of combustible wall coverings based on fire separation distances, radiant heat exposure and surface burning characteristics.

15.1 GENERAL

15.1.1 Scope.
The provisions of this part shall establish the minimum requirements for exterior walls; exterior wall coverings; exterior wall openings; exterior windows and doors; and architectural trim.

15.2 PERFORMANCE REQUIREMENTS

15.2.1 General.
The provisions of this clause shall apply to exterior walls, wall coverings and components thereof.

15.2.2 Weather protection.
Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing, as described in Clause 15.4.4. The exterior wall envelope shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a waterresistant barrier behind the exterior veneer, as described in Clause 15.3.2, and a means for draining water that enters the assembly to the exterior. Protection against condensation in the exterior wall assembly shall be provided in accordance with Clause 15.4.3.

Exceptions:
1. A weather-resistant exterior wall envelope shall not be required over concrete or masonry walls designed in accordance with Parts 20 and 22, respectively.
2. Compliance with the requirements for a means of drainage, and the requirements of Clauses 15.3.2 and 15.4.4, shall not be required for an exterior wall envelope that has been demonstrated through testing to resist wind-driven rain, including joints, penetrations and interclauses with dissimilar materials, in accordance with ASTM E331 under the following conditions:

2.1. Exterior wall envelope test assemblies shall include not less than one opening, one control joint, one wall/eave interface and one wall sill. Tested openings and penetrations shall be representative of the intended end-use configuration.

2.2. Exterior wall envelope test assemblies shall be not less than 4 feet by 8 feet (1219 mm by 2438 mm) in size.

2.3. Exterior wall envelope assemblies shall be tested at a minimum differential pressure of 6.24 pounds per square foot (psf) (0.297 \( kN/m^2 \)).

2.4. Exterior wall envelope assemblies shall be subjected to a minimum test exposure duration of 2 hours.

The exterior wall envelope design shall be considered to resist wind-driven rain where the results of testing indicate that water did not penetrate control joints in the exterior wall envelope, joints at the perimeter of openings or interclauses of terminations with dissimilar materials.

3. Exterior insulation and finish systems (EIFS) complying with Clause 15.7.4.1.

15.2.3 Structural.
Exterior walls, and the associated openings, shall be designed and constructed to resist safely the superimposed loads required by Part 17.

15.2.4 Fire resistance.
Exterior walls shall be fire-resistance rated as
required by other clauses of this Code with opening protection as required by Part 8.

15.2.5 Vertical and lateral flame propagation.

Exterior walls on buildings of Type I, II, III construction that are greater than 40 feet (12192 mm) in height above grade plane and contain a combustible water-resistant barrier shall be tested in accordance with and comply with the acceptance criteria of the Ghana Fire Code. For the purposes of this clause, fenestration products, flashing of fenestration products and water-resistive-barrier flashing and accessories at other locations, including through wall flashings, shall not be considered part of the water-resistant barrier.

Exceptions:

1. Walls in which the water-resistant barrier is the only combustible component and the exterior wall has a wall covering of brick, concrete, stone, terracotta, stucco or steel with minimum thicknesses in accordance with Table 15.4.2.

2. Walls in which the water-resistant barrier is the only combustible component and the water-resistant barrier has a peak heat release rate of less than 150 kW/m², a total heat release of less than 20 MJ/m² and an effective heat of combustion of less than 18 MJ/kg as determined in accordance with ASTM E1354 and has a flame spread index of 25 or less and a smoke-developed index of 450 or less as determined in accordance with ASTM E84. The ASTM E1354 test shall be conducted on specimens at the thickness intended for use, in the horizontal orientation and at an incident radiant heat flux of 50 kW/m².

15.2.6 Flood resistance.

For buildings in flood hazard areas as established in this Code, exterior walls extending below the elevation required by this Code shall be constructed with flood-damage-resistant materials.

15.2.7 Flood resistance for coastal high-hazard areas and coastal A zones.

For buildings in coastal high-hazard areas and coastal A zones as established in Clause 1612.3, electrical, mechanical and plumbing system components shall not be mounted on or penetrate through exterior walls that are designed to break away under flood loads.

15.3 MATERIALS

15.3.1 General.

Materials used for the construction of exterior walls shall comply with the provisions of this clause. Materials not prescribed herein shall be permitted, provided that any such alternative has been approved.

15.3.2 Water-resistant barrier.

Not fewer than one layer of No.15 asphalt felt, complying with ASTM D226 or Type 1 felt or other approved materials, shall be attached to the studs or sheathing, with flashing as described in Clause 15.4.4, in such a manner as to provide a continuous water-resistant barrier behind the exterior wall veneer.

15.3.3 Wood.

Exterior walls of wood construction shall be designed and constructed in accordance with Part 24.

15.3.3.1 Basic hardboard.

Basic hardboard shall conform to the requirements of GS 1029.

15.3.3.2 Hardboard siding.

Hardboard siding shall conform to the requirements of GS 1029 and, where used structurally, shall be so identified by the label of an approved agency.

15.3.4 Masonry.

Exterior walls of masonry construction shall be designed and constructed in accordance with this clause and Part 22. Masonry units, mortar and metal accessories used in anchored and adhered veneer shall meet the physical requirements of Part 22. The backing of anchored and adhered veneer shall be of concrete, masonry, steel framing or wood framing. Continuous insulation meeting the applicable requirements of this Code shall be...
permitted between the backing and the masonry veneer.

15.3.5 Metal.
Exterior walls constructed of cold-formed steel, structural steel or aluminum shall be designed in accordance with Parts 23 and 21, respectively.

15.3.5.1 Aluminum siding.
Aluminum siding shall conform to the requirements of this Code.

15.3.5.2 Cold-rolled copper.
Copper shall conform to the requirements of ASTM B370.

15.3.5.3 Lead-coated copper.
Lead-coated copper shall conform to the requirements of ASTM B101.

15.3.6 Concrete.
Exterior walls of concrete construction shall be designed and constructed in accordance with Part 20.

15.3.7 Glass-unit masonry.
Exterior walls of glass-unit masonry shall be designed and constructed in accordance with Part 22.

15.3.8 Plastics.
Plastic panel, apron or spandrel walls as defined in this Code shall not be limited in thickness, provided that such plastics and their assemblies conform to the requirements of Part 27 and are constructed of approved weather-resistant materials of adequate strength to resist the wind loads for cladding specified in this Code.

15.3.9 Vinyl siding.
Vinyl siding shall be certified and labeled as conforming to the requirements of ASTM D3679 by an approved quality control agency.

15.3.10 Fiber-cement siding.
Fiber-cement siding shall conform to the requirements of ASTM C1186, Type A (or ISO 8336, Category A), and shall be so identified on labeling listing an approved quality control agency.

15.3.11 Exterior insulation and finish systems.
Exterior insulation and finish systems (EIFS) and exterior insulation and finish systems (EIFS) with drainage shall comply with Clause 15.7.

15.3.12 Polypropylene siding.
Polypropylene siding shall be certified and labeled as conforming to the requirements of ASTM D7254 and those of Clause 15.3.12.1 or 15.3.12.2 by an approved quality control agency. Polypropylene siding shall be installed in accordance with the requirements of Clause 15.4.18 and in accordance with the manufacturer's instructions. Polypropylene siding shall be secured to the building so as to provide weather protection for the exterior walls of the building.

15.3.12.1 Flame spread index.
The certification of the flame spread index shall be accompanied by a test report stating that all portions of the test specimen ahead of the flame front remained in position during the test in accordance with ASTM E84.

15.3.12.2 Fire separation distance.
The fire separation distance between a building with polypropylene siding and the adjacent building shall be not less than 10 feet (3048 mm).

15.3.13 Foam plastic insulation.
Foam plastic insulation used in exterior wall covering assemblies shall comply with Part 27.

15.4 INSTALLATION OF WALL COVERINGS

15.4.1 General.
Exterior wall coverings shall be designed and constructed in accordance with the applicable provisions of this clause.

15.4.2 Weather protection.
Exterior walls shall provide weather protection for the building. The materials of the minimum nominal thickness specified in Table 15.4.2 shall be acceptable as approved weather coverings.

**TABLE 15.4.2: MINIMUM THICKNESS OF WEATHER COVERINGS**
<table>
<thead>
<tr>
<th>COVERING TYPE</th>
<th>MINIMUM THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhered masonry veneer</td>
<td></td>
</tr>
<tr>
<td>Architectural cast stone</td>
<td>0.75</td>
</tr>
<tr>
<td>Other</td>
<td>0.25</td>
</tr>
<tr>
<td>Aluminum siding</td>
<td>0.019</td>
</tr>
<tr>
<td>Anchored masonry veneer</td>
<td></td>
</tr>
<tr>
<td>Stone (natural)</td>
<td>2.0</td>
</tr>
<tr>
<td>Architectural cast stone</td>
<td>1.25</td>
</tr>
<tr>
<td>Other</td>
<td>2.625</td>
</tr>
<tr>
<td>Asbestos-cement boards</td>
<td>0.125</td>
</tr>
<tr>
<td>Asbestos shingles</td>
<td>0.156</td>
</tr>
<tr>
<td>Cold-rolled copper&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0216 nominal</td>
</tr>
<tr>
<td>Copper shingles&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.0162 nominal</td>
</tr>
<tr>
<td>Exterior plywood (with sheathing)</td>
<td>0.313</td>
</tr>
<tr>
<td>Exterior plywood (without sheathing)</td>
<td>See Section 2304.6</td>
</tr>
<tr>
<td>Fiber cement lap siding</td>
<td>0.25&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fiber cement panel siding</td>
<td>0.25&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fiberboard siding</td>
<td>0.5</td>
</tr>
<tr>
<td>Glass-fiber reinforced concrete panels</td>
<td>0.375</td>
</tr>
<tr>
<td>Hardboard siding&lt;sup&gt;+&lt;/sup&gt;</td>
<td>0.25</td>
</tr>
<tr>
<td>High-yield copper&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.0162 nominal</td>
</tr>
<tr>
<td>Lead-coated copper&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.0216 nominal</td>
</tr>
<tr>
<td>Lead-coated high-yield copper</td>
<td>0.0162 nominal</td>
</tr>
<tr>
<td>Marble slabs</td>
<td>1</td>
</tr>
<tr>
<td>Particleboard (with sheathing)</td>
<td>See Section 2304.6</td>
</tr>
<tr>
<td>Particleboard (without sheathing)</td>
<td>See Section 2304.6</td>
</tr>
<tr>
<td>Porcelain tile</td>
<td>0.25</td>
</tr>
<tr>
<td>Steel (approved corrosion resistant)</td>
<td>0.0149</td>
</tr>
<tr>
<td>Structural glass</td>
<td>0.344</td>
</tr>
<tr>
<td>Stucco or exterior cement plaster</td>
<td></td>
</tr>
<tr>
<td>Three-coat work over:</td>
<td></td>
</tr>
<tr>
<td>Metal plaster base</td>
<td>0.875&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unit masonry</td>
<td>0.625&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cast-in-place or precast concrete</td>
<td>0.625&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Two-coat work over:</td>
<td></td>
</tr>
<tr>
<td>Unit masonry</td>
<td>0.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cast-in-place or precast concrete</td>
<td>0.375&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Terra cotta (anchored)</td>
<td>1</td>
</tr>
<tr>
<td>Terra cotta (adhered)</td>
<td>0.25</td>
</tr>
<tr>
<td>Vinyl siding</td>
<td>0.035</td>
</tr>
<tr>
<td>Wood shingles</td>
<td>0.375</td>
</tr>
<tr>
<td>Wood siding (without sheathing)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.5</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 ounce = 28.35 g, 1 square foot = 0.093 m².

<sup>a</sup> Wood siding of thicknesses less than 0.5 inch shall be placed over sheathing that conforms to Clause 24.4.6.
<sup>b</sup> Exclusive of texture.
<sup>c</sup> As measured at the bottom of decorative grooves.
<sup>d</sup> 16 ounces per square foot for cold-rolled copper and lead-coated copper, 12 ounces per square foot for copper shingles, high-yield copper and lead-coated high-yield copper.
15.4.3 Vapour retarders.

Vapour retarders as described in Clause 15.4.3.3 shall be provided in accordance with Clauses 15.4.3.1 and 15.4.3.2, or an approved design using accepted engineering practice for hygrothermal analysis.

15.4.3.1 Class I and II vapour retarders.

Class I and II vapour retarders shall not be provided on the interior side of frame walls in Zones 1 and 2. Class I vapour retarders shall not be provided on the interior side of frame walls in Zones 3 and 4 other than Marine 4. Class I or II vapour retarders shall be provided on the interior side of frame walls in Zones 5, 6, 7, 8 and Marine 4. The appropriate zone shall be selected in accordance with Part 3 [CE] of the International Energy Conservation Code-Commercial Provisions.

Exceptions:

1. Basement walls.
2. Below-grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.
4. Conditions where Class III vapour retarders are required in Clause 15.4.3.2.

15.4.3.2 Class III vapour retarders.

Class III vapour retarders shall be permitted where any one of the conditions in Table 15.4.3.2 is met. Only Class III vapour retarders shall be used on the interior side of frame walls where foam plastic insulating sheathing with a perm rating of less than 1 is applied in accordance with Table 15.4.3.2 on the exterior side of the frame wall.

<table>
<thead>
<tr>
<th>ZONE</th>
<th>CLASS III VAPOUR RETARDERS PERMITTED FOR: a</th>
</tr>
</thead>
</table>
| Marine 4 | Vented cladding over wood structural panels  
Vented cladding over fiberboard  
Vented cladding over gypsum  
Continuous insulation with R-value $\geq$ R2.5 over 2 × 4 wall  
Continuous insulation with R-value $\geq$ R3.75 over 2 × 6 wall |
| 5 | Vented cladding over wood structural panels  
Vented cladding over fiberboard  
Vented cladding over gypsum  
Continuous insulation with R-value $\geq$ R5 over 2 × 4 wall  
Continuous insulation with R-value $\geq$ R7.5 over 2 × 6 wall |
| 6 | Vented cladding over fiberboard  
Vented cladding over gypsum  
Continuous insulation with R-value $\geq$ R7.5 over 2 × 4 wall  
Continuous insulation with R-value $\geq$ R11.25 over 2 × 6 wall |
| 7 and 8 | Continuous insulation with R-value $\geq$ R10 over 2 × 4 wall  
Continuous insulation with R-value $\geq$ R15 over 2 × 6 wall |

For SI: 1 pound per cubic foot = 16 kg/m$^3$.

a. Spray foam with a maximum permanence of 1.5 perms at the installed thickness applied to the interior cavity side of wood structural panels, fiberboard, insulating sheathing or gypsum is deemed to meet the continuous insulation requirement where the spray foam R-value meets or exceeds the specified insulating sheathing R-value.

15.4.3.3 Material vapour retarder class.

The vapour retarder class shall be based on the manufacturer’s certified testing or a tested assembly.

The following shall be deemed to meet the class specified:

Class I: Sheet polyethylene, nonperforated aluminum foil with a perm rating of less than or equal to 0.1.

Class II: Kraft-faced fiberglass batts or paint with a...
perm rating greater than 0.1 and less than or equal to 1.0.

Class III: Latex or enamel paint with a perm rating of greater than 1.0 and less than or equal to 10.0.

15.4.3.4 Minimum clear airspaces and vented openings for vented cladding.
For the purposes of this clause, vented cladding shall include the following minimum clear airspaces:

1. Vinyl, polypropylene or horizontal aluminum siding applied over a weather-resistive barrier as specified in this part.
2. Brick veneer with a clear airspace as specified in this Code.
3. Other approved vented claddings.

15.4.4 Flashing.
Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect that moisture to the exterior. Flashing shall be installed at the perimeters of exterior door and window assemblies, penetrations and terminations of exterior wall assemblies, exterior wall intercourses with roofs, chimneys, porches, decks, balconies and similar projections and at built-in gutters and similar locations where moisture could enter the wall. Flashing with projecting flanges shall be installed on both sides and the ends of copings, under sills and continuously above projecting trim. Where self-adhered membranes are used as flashings of fenestration in wall assemblies, those self-adhered flashings shall comply with AAMA 711. Where fluid applied membranes are used as flashing for exterior wall openings, those fluid applied membrane flashings shall comply with this Code.

15.4.4.1 Exterior wall pockets.
In exterior walls of buildings or structures, wall pockets or crevices in which moisture can accumulate shall be avoided or protected with caps or drips, or other approved means shall be provided to prevent water damage.

15.4.4.2 Masonry.
Flashing and weep holes in anchored veneer designed in accordance with Clause 15.4.6 shall be located not more than 10 inches (245 mm) above finished ground level above the foundation wall or slab. At other points of support including structural floors, shelf angles and lintels, flashing and weep holes shall be located in the first course of masonry above the support.

15.4.5 Wood veneers.
Wood veneers on exterior walls of buildings of Type I, II, III construction shall be not less than 1 inch (25 mm) nominal thickness, 0.438-inch (11.1 mm) exterior hardboard siding or 0.375-inch (9.5 mm) exterior-type wood structural panels or particleboard and shall conform to the following:

1. The veneer shall not exceed 40 feet (12 190 mm) in height above grade. Where fire-retardant-treated wood is used, the height shall not exceed 60 feet (18 290 mm) in height above grade.
2. The veneer is attached to or furred from a noncombustible backing that is fire-resistance rated as required by other provisions of this Code.
3. Where open or spaced wood veneers (without concealed spaces) are used, they shall not project more than 24 inches (610 mm) from the building wall.

15.4.6 Anchored masonry veneer.
Anchored masonry veneer shall comply with the provisions of Clauses 15.4.6 through 15.4.9.

15.4.6.1 Tolerances.
Anchored masonry veneers in accordance with Part 15 are not required to meet the tolerances in Article 3.3 F1 of TMS 602.

15.4.6.2 Seismic requirements.
Anchored masonry veneer located in Seismic Design Category C, D, E or F shall conform to the requirements of Clause 12.2.2.11 of TMS 402.

15.4.7 Stone veneer.
Anchored stone veneer units not exceeding 10 inches (254 mm) in thickness shall be anchored
1. With concrete or masonry backing, anchor ties shall be not less than 0.1055-inch (2.68 mm) corrosion-resistant wire, or approved equal, formed beyond the base of the backing. The legs of the loops shall be not less than 6 inches (152 mm) in length bent at right angles and laid in the mortar joint, and spaced so that the eyes or loops are 12 inches (305 mm) maximum on center in both directions. There shall be provided not less than a 0.1055-inch (2.68 mm) corrosion-resistant wire tie, or approved equal, threaded through the exposed loops for every 2 square feet (0.2 m²) of stone veneer. This tie shall be a loop having legs not less than 15 inches (381 mm) in length bent so that the tie will lie in the stone veneer mortar joint. The last 2 inches (51 mm) of each wire leg shall have a right-angle bend. One-inch (25 mm) minimum thickness of cement grout shall be placed between the backing and the stone veneer.

3. With cold-formed steel stud backing, a 2-inch by 2-inch (51 by 51 mm) 0.0625-inch (1.59 mm) zinc-coated or nonmetallic coated wire mesh with two layers of water-resistive barrier in accordance with Clause 15.3.2 shall be applied directly to steel studs spaced not more than 16 inches (406 mm) on center. The mesh shall be attached with corrosion-resistant #8 self-drilling, tapping screws at 4 inches (102 mm) on center, and at 8 inches (203 mm) on center into top and bottom tracks or with equivalent wire ties. Screws shall extend through the steel connection not fewer than three exposed threads. There shall be not less than a 0.1055-inch (2.68 mm) corrosion-resistant wire, or approved equal, attached to the stud with not smaller than a #8 self-drilling, tapping screw extending through the steel framing not fewer than three exposed threads for every 2 square feet (0.2 m²) of stone veneer. This tie shall be a loop having legs not less than 15 inches (381 mm) in length, so bent that the tie will lie in the stone veneer mortar joint. The last 2 inches (51 mm) of each wire leg shall have a right-angle bend. One-inch (25 mm) minimum thickness of cement grout shall be placed between the backing and the stone veneer.

15.4.8 Slab-type veneer.

Anchored slab-type veneer units not exceeding 2 inches (51 mm) in thickness shall be anchored directly to masonry, concrete or light-frame construction. For veneer units of marble, travertine, granite or other stone units of slab form, ties of corrosion-resistant dowels in drilled holes shall be located in the middle third of the edge of the units, spaced not more than 24 inches (610 mm) apart around the periphery of each unit with not less than four ties per veneer unit. Units shall not exceed 20 square feet (1.9 m²) in area. If the dowels are not tight fitting, the holes shall be drilled not more than 0.063 inch (1.6 mm) larger in diameter than the dowel, with the hole countersunk to a diameter and depth equal to twice the diameter of the dowel in order to provide a tight-fitting key of
cement mortar at the dowel locations where the mortar in the joint has set. Veneer ties shall be corrosion-resistant metal capable of resisting, in tension or compression, a force equal to two times the weight of the attached veneer. If made of sheet metal, veneer ties shall be not smaller in area than 0.0336 by 1 inch (0.853 by 25 mm) or, if made of wire, not smaller in diameter than 0.1483-inch (3.76 mm) wire.

15.4.9 Terra cotta.
Anchored terra cotta or ceramic units not less than 5/8 inches (41 mm) thick shall be anchored directly to masonry, concrete or stud construction. Tied terra cotta or ceramic veneer units shall be not less than 5/8 inches (41 mm) thick with projecting dovetail webs on the back surface spaced approximately 8 inches (203 mm) on center. The facing shall be tied to the backing wall with corrosion-resistant metal anchors of not less than No. 8 gage wire installed at the top of each piece in horizontal bed joints not less than 12 inches (305 mm) nor more than 18 inches (457 mm) on center; these anchors shall be secured to 1/4-inch (6.4 mm) corrosion-resistant pencil rods that pass through the vertical aligned loop anchors in the backing wall. The veneer ties shall have sufficient strength to support the full weight of the veneer in tension. The facing shall be set with not less than a 2-inch (51 mm) space from the backing wall and the space shall be filled solidly with Portland cement grout and pea gravel. Immediately prior to setting, the backing wall and the facing shall be drenched with clean water and shall be distinctly damp when the grout is poured.

15.4.10 Adhered masonry veneer.
Adhered masonry veneer shall comply with the applicable requirements in this clause and Clauses 12.1 and 12.2 of TMS 402.

15.4.10.1 Exterior adhered masonry veneer.
Exterior adhered masonry veneer shall be installed in accordance with Clause 15.4.10 and the manufacturer’s instructions.

15.4.10.1.1 Water-resistant barriers.
Water-resistant barriers shall be installed as required in Clause 26.10.6.

15.4.10.1.2 Flashing.
Flashing shall comply with the applicable requirements of Clause 15.4.4 and the following.

15.4.10.1.2.1 Flashing at foundation.
A corrosion-resistant screed or flashing of a minimum 0.019-inch (0.48 mm) or 26 gage galvanized or plastic with a minimum vertical attachment flange of 3/2 inches (89 mm) shall be installed to extend not less than 1 inch (25 mm) below the foundation plate line on exterior stud walls in accordance with Clause 15.4.4. The water-resistant barrier shall lap over the exterior of the attachment flange of the screed or flashing.

15.4.10.1.3 Clearances.
On exterior stud walls, adhered masonry veneer shall be installed not less than 4 inches (102 mm) above the earth, or not less than 2 inches (51 mm) above paved areas, or not less than 1/2 inch (12.7 mm) above exterior walking surfaces that are supported by the same foundation that supports the exterior wall.

15.4.10.1.4 Adhered masonry veneer installed with lath and mortar.
Exterior adhered masonry veneer installed with lath and mortar shall comply with the following.

15.4.10.1.4.1 Lathing.
Lathing shall comply with the requirements of Clause 26.10.

15.4.10.1.4.2 Scratch coat.
A nominal 1/2-inch-thick (12.7 mm) layer of mortar complying with the material requirements of Clauses 22.3 and 26.12.2 shall be applied, encapsulating the lathing. The surface of this mortar shall be scored horizontally, resulting in a scratch coat.

15.4.10.1.4.3 Adhering veneer.
The masonry veneer units shall be adhered to the mortar scratch coat with a nominal 1/2-inch-thick (12.7 mm) setting bed of mortar complying with Clauses 22.3 and 26.12.2 applied to create a full setting bed for the back of the masonry veneer units. The masonry veneer units shall be worked into the setting bed resulting in a
nominal $3/8$-inch (9.5 mm) setting bed after the masonry veneer units are applied.

15.4.10.1.5 Adhered masonry veneer applied directly to masonry and concrete.

Adhered masonry veneer applied directly to masonry or concrete shall comply with the applicable requirements of Clause 15.4.10 and with the requirements of Clause 15.4.10.1.4 or 26.10.7.

15.4.10.1.6 Cold weather construction.
Cold weather construction of adhered masonry veneer shall comply with the requirements of this Code.

15.4.10.1.7 Hot weather construction.
Hot weather construction of adhered masonry veneer shall comply with the requirements of this Code.

15.4.10.2 Exterior adhered masonry veneers—porcelain tile.
Adhered units shall not exceed $5/8$ inches (15.8 mm) thickness and 24 inches (610 mm) in any face dimension nor more than 3 square feet ($0.28 \text{ m}^2$) in total face area and shall not weigh more than 9 pounds psf ($0.43 \text{kN/m}^2$).
Porcelain tile shall be adhered to an approved backing system.

15.4.10.3 Interior adhered masonry veneers.
Interior adhered masonry veneers shall have a maximum weight of 20 psf ($0.958 \text{ kg/m}^2$) and shall be installed in accordance with Clause 15.4.10. Where the interior adhered masonry veneer is supported by wood construction, the supporting members shall be designed to limit deflection to $\frac{1}{600}$ of the span of the supporting members.

15.4.11 Metal veneers.

Veneers of metal shall be fabricated from approved corrosion-resistant materials or shall be protected front and back with porcelain enamel, or otherwise be treated to render the metal resistant to corrosion. Such veneers shall be not less than 0.0149-inch (0.378 mm) nominal thickness sheet steel mounted on wood or metal furring strips or approved sheathing on light-frame construction.

15.4.11.1 Attachment.

Exterior metal veneer shall be securely attached to the supporting masonry or framing members with corrosion-resistant fastenings, metal ties or by other approved devices or methods. The spacing of the fastenings or ties shall not exceed 24 inches (610 mm) either vertically or horizontally, but where units exceed 4 square feet ($0.4 \text{ m}^2$) in area there shall be not less than four attachments per unit. The metal attachments shall have a cross-clauseal area not less than provided by W 1.7 wire. Such attachments and their supports shall be designed and constructed to resist the wind loads as specified in Clause 1609 for components and cladding.

15.4.11.2 Weather protection.

Metal supports for exterior metal veneer shall be protected by painting, galvanizing or by other equivalent coating or treatment. Wood studs, furring strips or other wood supports for exterior metal veneer shall be approved pressure-treated wood or protected as required in Clause 15.2.2. Joints and edges exposed to the weather shall be caulked with approved durable waterproofing material or by other approved means to prevent penetration of moisture.

15.4.11.3 Backup.

Masonry backup shall not be required for metal veneer unless required by the fire-resistance requirements of this Code.

15.4.11.4 Grounding.

Grounding of metal veneers on buildings shall comply with the requirements of Part 27 of this Code.

15.4.12 Glass veneer.

The area of a single clause of thin exterior structural glass veneer shall not exceed 10 square feet ($0.93 \text{ m}^2$) where that clause is not more than 15 feet (4572 mm) above the level of the sidewalk or grade level directly below, and shall not exceed 6 square feet ($0.56 \text{ m}^2$) where it is more than 15 feet (4572 mm) above that level.

15.4.12.1 Length and height.
The length or height of any clause of thin
exterior structural glass veneer shall not exceed 48 inches (1219 mm).

15.4.12.2 Thickness.
The thickness of thin exterior structural glass veneer shall be not less than 0.344 inch (8.7 mm).

15.4.12.3 Application.
Thin exterior structural glass veneer shall be set only after backing is thoroughly dry and after application of an approved bond coat uniformly over the entire surface of the backing so as to effectively seal the surface. Glass shall be set in place with an approved mastic cement in sufficient quantity so that not less than 50 percent of the area of each glass unit is directly bonded to the backing by mastic not less than 1/4 inch (6.4 mm) thick and not more than 5/8 inch (15.9 mm) thick. The bond coat and mastic shall be evaluated for compatibility and shall bond firmly together.

15.4.12.4 Installation at sidewalk level.
Where glass extends to a sidewalk surface, each clause shall rest in an approved metal molding, and be set not less than 1/4 inch (6.4 mm) above the highest point of the sidewalk. The space between the molding and the sidewalk shall be thoroughly caulked and made water tight.

15.4.12.4.1 Installation above sidewalk level.
Where thin exterior structural glass veneer is installed above the level of a bulkhead facing, or at a level more than 36 inches (914 mm) above the sidewalk level, the mastic cement binding shall be supplemented with approved nonferrous metal shelf angles located in the horizontal joints in every course. Such shelf angles shall be not less than 0.0478-inch (1.2 mm) thick and not less than 2 inches (51 mm) long and shall be spaced at approved intervals, with not less than two angles for each glass unit. Shelf angles shall be secured to the wall or backing with expansion bolts, toggle bolts or by other approved methods.

15.4.12.5 Joints.
Unless otherwise specifically approved by the building official, abutting edges of thin exterior structural glass veneer shall be ground square.

Mitered joints shall not be used except where specifically approved for wide angles. Joints shall be uniformly buttered with an approved jointing compound and horizontal joints shall be held to not less than 0.063 inch (1.6 mm) by an approved nonrigid substance or device. Where thin exterior structural glass veneer abuts nonresilient material at sides or top, expansion joints not less than 1/4 inch (6.4 mm) wide shall be provided.

15.4.12.6 Mechanical fastenings.
Thin exterior structural glass veneer installed above the level of the heads of show windows and finish installed more than 12 feet (3658 mm) above sidewalk level shall, in addition to the mastic cement and shelf angles, be held in place by the use of fastenings at each vertical or horizontal edge, or at the four corners of each glass unit. Fastenings shall be secured to the wall or backing with expansion bolts, toggle bolts or by other methods. Fastenings shall be so designed as to hold the glass veneer in a vertical plane independent of the mastic cement. Shelf angles providing both support and fastenings shall be permitted.

15.4.12.6 Flashing.
Exposed edges of thin exterior structural glass veneer shall be flashed with overlapping corrosion-resistant metal flashing and caulked with a waterproof compound in a manner to effectively prevent the entrance of moisture between the glass veneer and the backing.

15.4.13 Exterior windows and doors.
Windows and doors installed in exterior walls shall conform to the testing and performance requirements of Clause 19.9.5.

15.4.13.1 Installation.
Windows and doors shall be installed in accordance with approved manufacturer’s instructions. Fastener size and spacing shall be provided in such instructions and shall be calculated based on maximum loads and spacing used in the tests.

15.4.14 Vinyl siding.
Vinyl siding conforming to the requirements of this clause and complying with ASTM D3679 shall be permitted on exterior walls of buildings located in areas where V... as determined in...
accordance with this Code does not exceed 100 miles per hour (45 m/s) and the building height is less than or equal to 40 feet (12 192 mm) in Exposure C. Where construction is located in areas where wind speed exceeds 100 miles per hour (45 m/s), or building heights are in excess of 40 feet (12 192 mm), tests or calculations indicating compliance with this Code shall be submitted. Vinyl siding shall be secured to the building so as to provide weather protection for the exterior walls of the building.

### 15.4.14.1 Application.

The siding shall be applied over sheathing or materials listed in Clause 24.4.6. Siding shall be applied to conform to the water-resistive barrier requirements in Clause 15.2. Siding and accessories shall be installed in accordance with approved manufacturer's instructions. Unless otherwise specified in the approved manufacturer's instructions, nails used to fasten the siding and accessories shall have a minimum 0.313-inch (7.9 mm) head diameter and 1/8-inch (3.18 mm) shank diameter. The nails shall be corrosion resistant and shall be long enough to penetrate the studs or nailing strip not less than 3/4 inch (19 mm). For cold-formed steel light-frame construction, corrosion-resistant fasteners shall be used. Screw fasteners shall penetrate the cold-formed steel framing not fewer than three exposed threads. Other fasteners shall be installed in accordance with the approved construction documents and manufacturer's instructions.

### 15.4.16.1 Panel siding.

Fiber-cement panels shall comply with the requirements of ASTM C1186, Type A, minimum Grade II (or ISO 8336, Category A, minimum Class 2). Panels shall be installed with the long dimension either parallel or perpendicular to framing. Vertical and horizontal joints shall occur over framing members and shall be protected with caulking, with battens or flashing, or be vertical or horizontal shiplap or otherwise designed to comply with Clause 15.2.2. Panel siding shall be installed with fasteners in accordance with the approved manufacturer's instructions.

### 15.4.16.2 Lap siding.

Fiber-cement lap siding having a maximum width of 12 inches (305 mm) shall comply with the requirements of ASTM C1186, Type A, minimum Grade II (or ISO 8336, Category A, minimum Class 2). Lap siding shall be lapped not less than 1/4 inches (32 mm) and lap siding not having tongue-and-groove end joints shall have the ends protected with caulking, covered with an H-clause joint cover, located over a strip of flashing or shall be otherwise designed to comply with Clause 15.2.2. Lap siding courses shall be installed with the fastener heads exposed or concealed in accordance with the approved manufacturer's instructions.
15.4.17 Fastening.

Weather boarding and wall coverings shall be securely fastened with aluminum, copper, zinc, zinc-coated or other approved corrosion-resistant fasteners in accordance with the nailing schedule in this Code or the approved manufacturer's instructions. Shingles and other weather coverings shall be attached with appropriate standard-shingle nails to furring strips securely nailed to studs, or with approved mechanically bonding nails, except where sheathing is of wood not less than 1-inch (25 mm) nominal thickness or of wood structural panels as specified in Table 24.8.6.3(3).

15.4.18 Polypropylene siding.

Polypropylene siding conforming to the requirements of this clause and complying with Clause 15.3.12 shall be limited to exterior walls located in areas where the wind speed specified in Part 16 does not exceed 100 miles per hour (45 m/s) and the building height is less than or equal to 40 feet (12 192 mm) in Exposure C. Where construction is located in areas where the basic wind speed exceeds 100 miles per hour (45 m/s), tests or calculations indicating compliance with Part 16 shall be submitted. Polypropylene siding shall be installed in accordance with the manufacturer's instructions. Polypropylene siding shall be secured to the building so as to provide weather protection for the exterior walls of the building.

15.5 COMBUSTIBLE MATERIALS ON THE EXTERIOR SIDE OF EXTERIOR WALLS

15.5.1 Combustible exterior wall coverings.

Combustible exterior wall coverings shall comply with this clause.

Exception: Plastics complying with Part 27.

15.5.1.1 Types I, II and III construction.

On buildings of Types I, II and III construction, exterior wall coverings shall be permitted to be constructed of combustible materials, complying with the following limitations:

1. Combustible exterior wall coverings shall not exceed 10 percent of an exterior wall surface area where the fire separation distance is 5 feet (1524 mm) or less.

2. Combustible exterior wall coverings shall be limited to 40 feet (12 192 mm) in height above grade plane.

3. Combustible exterior wall coverings constructed of fire-retardant-treated wood complying with this Code for exterior installation shall not be limited in wall surface area where the fire separation distance is 5 feet (1524 mm) or less and shall be permitted up to 60 feet (18 288 mm) in height above grade plane regardless of the fire separation distance.

4. Wood veneers shall comply with Clause 15.4.5.

15.5.1.1.1 Ignition resistance.

Where permitted by Clause 15.5.1.1, combustible exterior wall coverings shall be tested in accordance with the Ghana Fire Code.

Exceptions:

1. Wood or wood-based products.

2. Other combustible materials covered with an exterior weather covering, other than vinyl sidings, included in and complying with the thickness requirements of Table 15.4.2.

3. Aluminum having a minimum thickness of 0.019 inch (0.48 mm).

15.5.1.1.1.1 Fire separation 5 feet or less.

Where installed on exterior walls having a fire separation distance of 5 feet (1524 mm) or less, combustible exterior wall coverings shall not exhibit sustained flaming as defined in this Code.

15.5.1.1.1.2 Fire separation greater than 5 feet.

For fire separation distances greater than 5 feet (1524 mm), any exterior wall covering shall be permitted that has been exposed to a reduced level of incident radiant heat flux in accordance with the this Code test method without exhibiting sustained flaming. The minimum fire
separation distance required for the exterior wall covering shall be determined from Table 15.5.1.1.2 based on the maximum tolerable level of incident radiant heat flux that does not cause sustained flaming of the exterior wall covering.

### TABLE 15.5.1.1.2: MINIMUM FIRE SEPARATION FOR COMBUSTIBLE EXTERIOR WALL COVERINGS

<table>
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<tr>
<th>FIRE SEPARATION DISTANCE (feet)</th>
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For SI: 1 foot = 304.8 mm, 1 Btu/H \(^2\cdot\)°F = 0.0057 kW/m\(^2\cdot\)K.

### 15.5.1.2 Location.
Combustible exterior wall coverings located along the top of exterior walls shall be completely backed up by the exterior wall and shall not extend over or above the top of the exterior wall.

### 15.5.1.3 Fireblocking.
Where the combustible exterior wall covering is furred out from the exterior wall and forms a solid surface, the distance between the back of the exterior wall covering and the exterior wall shall not exceed \(\frac{5}{8}\) inches (41 mm). The concealed space thereby created shall be fireblocked in accordance with Clause 718.
Exception: The distance between the back of the exterior wall covering and the exterior wall shall be permitted to exceed \( \frac{5}{8} \) inches (41 mm) where the concealed space is not required to be fireblocked by Clause 8.18.

15.6 METAL COMPOSITE MATERIALS (MCM)

15.6.1 General.
The provisions of this clause shall govern the materials, construction and quality of metal composite materials (MCM) for use as exterior wall coverings in addition to other applicable requirements of Parts 14 and 16.

15.6.2 Exterior wall finish.
MCM used as exterior wall finish or as elements of balconies and similar projections and bay and oriel windows to provide cladding or weather resistance shall comply with Clauses 15.6.4 through 15.6.14.

15.6.3 Architectural trim and embellishments.
MCM used as architectural trim or embellishments shall comply with Clauses 15.6.7 through 15.6.14.

15.6.4 Structural design.
MCM systems shall be designed and constructed to resist wind loads as required by Part 16 for components and cladding.

15.6.5 Approval.
Results of approved tests or an engineering analysis shall be submitted to the building official to verify compliance with the requirements of Part 16 for wind loads.

15.6.6 Weather resistance.
MCM systems shall comply with Clause 15.2 and shall be designed and constructed to resist wind and rain in accordance with this clause and the manufacturer’s installation instructions.

15.6.7 Durability.
MCM systems shall be constructed of approved materials that maintain the performance characteristics required in Clause 15.6 for the duration of use.

15.6.8 Fire-resistance rating.
Where MCM systems are used on exterior walls required to have a fire-resistance rating in accordance with Clause 8.5, evidence shall be submitted to the building official that the required fire-resistance rating is maintained.

Exception: MCM systems not containing foam plastic insulation, which are installed on the outer surface of a fire-resistance-rated exterior wall in a manner such that the attachments do not penetrate through the entire exterior wall assembly, shall not be required to comply with this clause.

15.6.9 Surface-burning characteristics.
Unless otherwise specified, MCM shall have a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in the maximum thickness intended for use in accordance with ASTM E84.

15.6.10 Type I, II and III construction.
Where installed on buildings of Type I, II and III construction, MCM systems shall comply with Clauses 15.6.10.1 through 15.6.10.4, or Clause 15.6.11.

15.6.10.1 Surface-burning characteristics.
MCM shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450 when tested as an assembly in the maximum thickness intended for use in accordance with ASTM E84.

15.6.10.2 Thermal barriers.
MCM shall be separated from the interior of a building by an approved thermal barrier consisting of \( \frac{1}{2} \) -inch (12.7 mm) gypsum wallboard or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of the Ghana Fire Code.

15.6.10.3 Thermal barrier not required.
The thermal barrier specified for MCM in Clause 15.6.10.2 is not required where:

1. The MCM system is specifically approved based on tests conducted in accordance with ASTM E84 and with the acceptance criteria of this Code. Such testing shall be performed with the MCM in the maximum thickness intended for use. The MCM system shall include seams, joints and other typical details used in the installation and shall be tested in the manner intended for use.
2. The MCM is used as elements of balconies and similar projections, architectural trim or embellishments.

15.6.10.4 Full-scale tests. The MCM system shall be tested in accordance with, and comply with, the acceptance criteria of this Code. Such testing shall be performed on the MCM system with the MCM in the maximum thickness intended for use.

15.6.11 Alternate conditions. MCM and MCM systems shall not be required to comply with Clauses 15.6.10.1 through 15.6.10.4 provided that such systems comply with Clause 15.6.11.1, 15.6.11.2, 15.6.11.3 or 15.6.11.4.

15.6.11.1 Installations up to 40 feet in height. MCM shall not be installed more than 40 feet (12 190 mm) in height above grade where installed in accordance with Clauses 15.6.11.1.1 and 15.6.11.1.2.

15.6.11.1.1 Fire separation distance of 5 feet or less. Where the fire separation distance is 5 feet (1524 mm) or less, the area of MCM shall not exceed 10 percent of the exterior wall surface.

15.6.11.1.2 Fire separation distance greater than 5 feet. Where the fire separation distance is greater than 5 feet (1524 mm), the area of exterior wall surface coverage using MCM shall not be limited.

15.6.11.2 Installations up to 50 feet in height. MCM shall not be installed more than 50 feet (15 240 mm) in height above grade where installed in accordance with Clauses 15.6.11.2.1 and 15.6.11.2.2.

15.6.11.2.1 Self-ignition temperature. MCM shall have a self-ignition temperature of 650°F (343°C) or greater when tested in accordance with ASTM D1929.

15.6.11.2.2 Limitations. Clauses of MCM shall not exceed 300 square feet (27.9 m²) in area and shall be separated by not less than 4 feet (1219 mm) vertically.

15.6.11.3 Installations up to 75 feet in height (Option 1). MCM shall not be installed more than 75 feet (22 860 mm) in height above grade plane where installed in accordance with Clauses 15.6.11.3.1 through 15.6.11.3.5.

Exception: Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 shall be exempt from the height limitation.

15.6.11.3.1 Prohibited occupancies. MCM shall not be permitted on buildings classified as Group A-1, A-2, H, I-2 or I-3 occupancies.

15.6.11.3.2 Nonfire-resistance-rated exterior walls. MCM shall not be permitted on exterior walls required to have a fire-resistance rating by other provisions of this Code.

15.6.11.3.3 Specifications. MCM shall be required to comply with all of the following:

1. MCM shall have a self-ignition temperature of 650°F (343°C) or greater when tested in accordance with ASTM D1929.

2. MCM shall conform to one of the following combustibility classifications when tested in accordance with ASTM D635:

   Class CC1: Materials that have a burning extent of 1 inch (25 mm) or less when tested at a nominal thickness of 0.060 inch (1.5 mm) or in the thickness intended for use.

   Class CC2: Materials that have a burning rate of \( \frac{2}{\sqrt{2}} \) inches per minute (1.06 mm/s) or less when tested at a nominal thickness of 0.060 inch (1.5 mm) or in the thickness intended for use.

15.6.11.3.4 Area limitation and separation. The maximum area of a single MCM panel and the minimum vertical and horizontal separation requirements for MCM panels shall be as provided for in Table 15.6.11.3.4. The maximum percentage of exterior wall area of any storey covered with MCM panels shall not exceed that indicated in Table 15.6.11.3.4 or the percentage of unprotected openings permitted by this Code, whichever is smaller.
### TABLE 15.6.11.3.4: AREA LIMITATION AND SEPARATION REQUIREMENTS FOR MCM PANELS

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE (feet)</th>
<th>COMBUSTIBILITY CLASS OF MCM</th>
<th>MAXIMUM PERCENTAGE AREA OF EXTERIOR WALL COVERED WITH MCM PANELS</th>
<th>MAXIMUM SINGLE AREA OF MCM PANELS (square feet)</th>
<th>MINIMUM SEPARATION OF MCM PANELS (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vertical</td>
</tr>
<tr>
<td>Less than 6</td>
<td>—</td>
<td>Not Permitted</td>
<td>Not Permitted</td>
<td>—</td>
</tr>
<tr>
<td>6 or more but less than 11</td>
<td>CC1</td>
<td>10</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>CC2</td>
<td>Not Permitted</td>
<td>Not Permitted</td>
<td>—</td>
</tr>
<tr>
<td>11 or more but less than or equal to 30</td>
<td>CC1</td>
<td>25</td>
<td>90</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>CC2</td>
<td>15</td>
<td>70</td>
<td>8</td>
</tr>
<tr>
<td>More than 30</td>
<td>CC1</td>
<td>50</td>
<td>Not Limited</td>
<td>3⁵</td>
</tr>
<tr>
<td></td>
<td>CC2</td>
<td>50</td>
<td>100</td>
<td>6⁵</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m².

a. For reductions in the minimum vertical separation, see Clause 15.6.11.3.4.

**Exception:** In buildings provided with flame barriers complying with Clause 8.5.8.5 and extending 30 inches (760 mm) beyond the exterior wall in the plane of the floor, a vertical separation shall not be required at the floor other than that provided by the vertical thickness of the flame barrier.

#### 15.6.11.3.5 Automatic sprinkler system increases.

Where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the maximum percentage area of exterior wall of any storey covered with MCM panels and the maximum square footage of a single area of MCM panels in Table 15.6.11.3.4 shall be increased 100 percent. The area of MCM panels shall not exceed 50 percent of the exterior wall area of any storey or the area permitted by this Code for unprotected openings, whichever is smaller.

#### 15.6.11.4 Installations up to 75 feet in height (Option 2).

MCM shall not be installed more than 75 feet (22 860 mm) in height above grade plane where installed in accordance with Clauses 15.6.11.4.1 through 15.6.11.4.4.

**Exception:** Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 shall be exempt from the height limitation.

#### 15.6.11.4.1 Minimum fire separation distance.

MCM shall not be installed on any wall with a fire separation distance less than 30 feet (9 144 mm).

**Exception:** Where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the fire
separation distance shall be permitted to be reduced to not less than 20 feet (6096 mm).

15.6.11.4.2 Specifications.
MCM shall be required to comply with all of the following:

1. MCM shall have a self-ignition temperature of 650°F (343°C) or greater when tested in accordance with ASTM D1929.

2. MCM shall conform to one of the following combustibility classifications when tested in accordance with ASTM D635:
   - Class CC1: Materials that have a burning extent of 1 inch (25 mm) or less when tested at a nominal thickness of 0.060 inch (1.5 mm), or in the thickness intended for use.
   - Class CC2: Materials that have a burning rate of $\frac{1}{2}$ inches per minute (1.06 mm/s) or less when tested at a nominal thickness of 0.060 inch (1.5 mm), or in the thickness intended for use.

15.6.11.4.3 Area and size limitations.
The aggregate area of MCM panels shall not exceed 25 percent of the area of any exterior wall face of the storey on which those panels are installed. The area of a single MCM panel installed above the first storey above grade plane shall not exceed 16 square feet (1.5 m$^2$) and the vertical dimension of a single MCM panel shall not exceed 4 feet (1219 mm).

**Exception:** Where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the maximum aggregate area of MCM panels shall be increased to 50 percent of the exterior wall face of the storey on which those panels are installed and there shall not be a limit on the maximum dimension or area of a single MCM panel.

15.6.11.4.4 Vertical separations.
Flame barriers complying with Clause 8.5.8 and extending 30 inches (762 mm) beyond the exterior wall or a vertical separation of not less than 4 feet (1219 mm) in height shall be provided to separate MCM panels located on the exterior walls at one-storey intervals.

**Exception:** Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

15.6.13 Foam plastic insulation.
MCM systems containing foam plastic insulation shall also comply with the requirements of Clause 27.3.

15.6.14 Labeling.
MCM shall be labeled in accordance with Clause 19.3.5.

**15.7 EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS)**

15.7.1 General.
The provisions of this clause shall govern the materials, construction and quality of exterior insulation and finish systems (EIFS) for use as exterior wall coverings in addition to other applicable requirements of Parts 7, 14, 16, 17 and 26.

15.7.2 Performance characteristics.
EIFS shall be constructed such that it meets the performance characteristics required in ASTM E2568.

15.7.3 Structural design.
The underlying structural framing and substrate shall be designed and constructed to resist loads as required by Part 16.

15.7.4 Weather resistance.
EIFS shall comply with Clause 15.2 and shall be designed and constructed to resist wind and rain in accordance with this clause and the manufacturer’s application instructions.

15.7.4.1 EIFS with drainage.
EIFS with drainage shall have an average minimum drainage efficiency of 90 percent when tested in accordance the requirements of ASTM E2273 and is required on framed walls of Type IV construction, Group R1, R2, R3 and R4 occupancies.

15.7.4.1.1 Water-resistive barrier.
For EIFS with drainage, the water-resistive barrier shall comply with Clause 15.3.2 or ASTM E2570.

15.7.5 Installation.
Installation of the EIFS and EIFS with drainage
shall be in accordance with the EIFS manufacturer's instructions.

15.7.6 Special inspections. EIFS installations shall comply with the provisions of Clauses 19.4.2 and 19.5.16.

15.8 HIGH-PRESSURE DECORATIVE EXTERIOR-GRADE COMPACT LAMINATES (HPL)

15.8.1 General. The provisions of this clause shall govern the materials, construction and quality of High-Pressure Decorative Exterior-Grade Compact Laminates (HPL) for use as exterior wall coverings in addition to other applicable requirements of Parts 14 and 16.

15.8.2 Exterior wall finish. HPL used as exterior wall covering or as elements of balconies and similar projections and bay and oriel windows to provide cladding or weather resistance shall comply with Clauses 15.8.4 through 15.8.14.

15.8.3 Architectural trim and embellishments. HPL used as architectural trim or embellishments shall comply with Clauses 15.8.7 through 15.8.14.

15.8.4 Structural design. HPL systems shall be designed and constructed to resist wind loads as required by Part 16 for components and cladding.

15.8.5 Approval. Results of approved tests or an engineering analysis shall be submitted to the building official to verify compliance with the requirements of Part 16 for wind loads.

15.8.6 Weather resistance. HPL systems shall comply with Clause 15.2 and shall be designed and constructed to resist wind and rain in accordance with this clause and the manufacturer’s instructions.

15.8.7 Durability. HPL systems shall be constructed of approved materials that maintain the performance characteristics required in Clause 15.8 for the duration of use.

15.8.8 Fire-resistance rating. Where HPL systems are used on exterior walls required to have a fire-resistance rating in accordance with this Code, evidence shall be submitted to the building official that the required fire-resistance rating is maintained.

Exception: HPL systems not containing foam plastic insulation, which are installed on the outer surface of a fire-resistance-rated exterior wall in a manner such that the attachments do not penetrate through the entire exterior wall assembly, shall not be required to comply with this clause.

15.8.9 Surface-burning characteristics. Unless otherwise specified, HPL shall have a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in the minimum and maximum thicknesses intended for use in accordance with ASTM E84.

15.8.10 Type I, II and III construction. Where installed on buildings of Type I, II and III construction, HPL systems shall comply with Clauses 15.8.10.1 through 15.8.10.4, or Clause 15.8.11.

15.8.10.1 Surface-burning characteristics. HPL shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450 when tested in the minimum and maximum thicknesses intended for use in accordance with ASTM E84.

15.8.10.2 Thermal barriers. HPL shall be separated from the interior of a building by an approved thermal barrier consisting of \( \frac{1}{2} \) -inch (12.7 mm) gypsum wallboard or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of the Ghana Fire Code.

15.8.10.3 Thermal barrier not required. The thermal barrier specified for HPL in Clause 15.8.10.2 is not required where:

1. The HPL system is specifically approved based on tests conducted in accordance with this Code. Such testing shall be performed with the HPL in the minimum and maximum thicknesses intended for use. The HPL system shall include seams, joints and other typical details used in the installation and shall be tested in the manner intended for use.

2. The HPL is used as elements of balconies and similar projections,
15.8.10.4 Full-scale tests.
The HPL system shall be tested in accordance with and comply with, the acceptance criteria of the Ghana Fire Code. Such testing shall be performed on the HPL system with the HPL in the minimum and maximum thicknesses intended for use.

15.8.11 Alternate conditions.
HPL and HPL systems shall not be required to comply with Clauses 15.8.10.1 through 15.8.10.4 provided that such systems comply with Clause 15.8.11.1 or 15.8.11.2.

15.8.11.1 Installations up to 40 feet in height.
HPL shall not be installed more than 40 feet (12 190 mm) in height above grade plane where installed in accordance with Clauses 15.8.11.1.1 and 15.8.11.1.2.

15.8.11.1.1 Fire separation distance of 5 feet or less.
Where the fire separation distance is 5 feet (1524 mm) or less, the area of HPL shall not exceed 10 percent of the exterior wall surface.

15.8.11.1.2 Fire separation distance greater than 5 feet.
Where the fire separation distance is greater than 5 feet (1524 mm), the area of exterior wall surface coverage using HPL shall not be limited.

15.8.11.2 Installations up to 50 feet in height.
HPL shall not be installed more than 50 feet (15 240 mm) in height above grade plane where installed in accordance with Clauses 15.8.11.2.1 and 15.8.11.2.2.

15.8.11.2.1 Self-ignition temperature.
HPL shall have a self-ignition temperature of 650°F (343°C) or greater when tested in accordance with ASTM D1929.

15.8.11.2.2 Limitations.
Clauses of HPL shall not exceed 300 square feet (27.9 m²) in area and shall be separated by a minimum 4 feet (1219 mm) vertically.

15.8.13 Foam plastic insulation.
HPL systems containing foam plastic insulation shall comply with the requirements of Clause 27.3.

15.8.14 Labeling.
HPL shall be labeled in accordance with Clause 19.3.5.

15.9 PLASTIC COMPOSITE DECKING

15.9.1 Plastic composite decking.
Exterior deck boards, stair treads, handrails and guards constructed of plastic composites, including plastic timber, shall comply with Clause 27.12.

15.10 BUILDING ENVELOPE SYSTEMS

15.10.1 Prescriptive compliance.
Where buildings are designed using the prescriptive-based compliance path in accordance with this Code, building thermal envelope systems shall comply with the provisions of this clause.

15.10.1.1 Insulation and fenestration criteria.
The building thermal envelope shall exceed the requirements of this Code by not less than 5 percent. Specifically, for purposes of compliance with this Code, each U-factor, C-factor, F-factor and SHGC in the specified tables shall be reduced by 5 percent to determine the prescriptive criteria for this Code. Where this Code provides for no requirement (NR) for the R-value of an assembly, the U-factor, C-factor and F-factor are not required to be reduced. In Sky Type “C” locations specified in Clause 808.4, the skylights shall not exceed 5 percent of the building roof area.

15.10.1.1.1 Shading devices for fenestration.
Vertical fenestration within 135 degrees (3316 rad) of the nearest south cardinal ordinate in buildings located in the northern hemisphere or the nearest north cardinal ordinate in buildings located in the southern hemisphere, shall be shaded by one or a combination of the following methods:

1. Permanent horizontal exterior projections with a projection factor greater than or equal to 0.25. Where different windows or glass doors have different projection factor values, each shall be evaluated separately, or an area-weighted projection
factor value shall be calculated and used for all windows and glass doors. Horizontal projections shall extend laterally beyond the edge of the glazing not less than one-half of the height of the glazing, except at building corners.

2. Automatically controlled shading devices capable of modulating in multiple steps the amount of solar gain and light transmitted into the space in response to daylight levels or solar intensity, that comply with all of the following:

2.1. Exterior shading devices in the closed position shall cover not less than 90 percent of the fenestration.

2.2. Interior shading devices in the closed position shall cover not less than 90 percent of the fenestration and have a minimum solar reflectance of 0.50 for the surface facing the fenestration.

2.3. A manual override, where provided, shall override operation of automatic controls for not longer than 4 hours.

2.4. Commissioning shall be conducted as required by Clause 7.11.10 to verify that the automatic controls for shading devices respond to changes in illumination or radiation intensity.

Exception: Shading devices are not required for the following buildings and fenestrations:

1. Buildings located in hurricane-prone regions in accordance with this Code or on any other building with a mean roof height exceeding the height limits specified in Table 16.4.8 of the In this Code based on the exposure category and basic wind speed at the building site.

2. Where fenestration is located in a building wall that is within 457 mm (18 inches) of the plot line.

3. Where equivalent shading of the fenestration is provided by buildings, man-made structures, geological formations, or permanent exterior projections that are not horizontal, as determined by sun angle studies at the peak solar altitude on the spring equinox, and three hours before and after the peak solar altitude on the spring equinox.

4. Where fenestration contains dynamic glazing that has a lower labeled solar heat gain coefficient (SHGC) equal to or less than 0.12, and the ratio of the higher and lower labeled visible transmittance (VT) is greater than or equal to 5. Dynamic glazing shall be automatically controlled to modulate, in multiple steps, the amount of solar gain and light transmitted into the space in response to daylight levels or solar intensity. Functional testing of the controls of the dynamic glazing shall be conducted in accordance with this Code.

15.10.1.2 Air leakage.

The building thermal envelope shall be durably sealed to limit air leakage in accordance with this Code and the provisions of this clause.

15.10.1.2.1 Air barriers.

A continuous air barrier shall be provided for buildings in climate zones 1 through 8 in accordance with this Code.

15.10.1.2.2 Testing requirement.

The building thermal envelope air tightness shall be tested and the air leakage rate of the total area of the building thermal envelope shall
not exceed 0.25 cfm/ft² under a pressure differential of 0.3-inch water column (1.57 lb/ft²) (1.25 L/s.m² under a pressure differential of 75 Pa). Testing shall occur after rough-in and after installation of penetrations of the building envelope, including penetrations for utilities, heating, ventilating and air-conditioning (HVAC) systems, plumbing, and electrical equipment and appliances. Testing shall be done in accordance with ASTM E779. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the Code official and the building owner. Where the tested rate exceeds 0.25 cfm/ft², a visual inspection of the air barrier shall be conducted and any leaks noted shall be sealed to the extent practicable. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the Code official and the building owner, and shall be deemed to satisfy the requirements of this clause.

15.10.1.2.3 Air curtains.

Where air curtains are provided at building entrances or building entrance vestibules, the curtain shall have a minimum velocity of 2 m/s at the floor, be tested in accordance with this Code and installed in accordance with the manufacturer’s instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with this Code.
PART 16: ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

User notes:
About this part: Part 16 provides minimum requirements for the design and construction of roof assemblies and rooftop structures. The criteria address the weather-protective barrier at the roof and, in most circumstances, a fire-resistant barrier. It also recognizes newer products such as photovoltaic shingles. Clause 16.10 addresses rooftop structures, which include penthouses, tanks, towers and spires. Rooftop penthouses larger than prescribed in this part must be treated as a storey under Part 6.

16.1 GENERAL

16.1.1 Scope.
The provisions of this part shall govern the design, materials, construction and quality of roof assemblies, and rooftop structures.

16.2 ROOF DRAINAGE

16.2.1 General.
Design and installation of roof drainage systems shall comply with Clause 16.2 of this Code.

16.2.2 Secondary (emergency overflow) drains or scuppers.
Where roof drains are required, secondary (emergency overflow) roof drains or scuppers shall be provided where the roof perimeter construction extends above the roof in such a manner that water will be entrapped if the primary drains allow buildup for any reason. The installation and sizing of secondary emergency overflow drains, leaders and conductors shall comply with this Code.

16.2.3 Scuppers.
Where scuppers are used for secondary (emergency overflow) roof drainage, the quantity, size, location and inlet elevation of the scuppers shall be sized to prevent the depth of ponding water from exceeding that for which the roof was designed as determined by Clause 16.11.1. Scuppers shall not have an opening dimension of less than 102 mm (4 inches). The flow through the primary system shall not be considered when locating and sizing scuppers.

16.2.4 Gutters.
Gutters and leaders placed on the outside of buildings, other than Group R-3, private garages and buildings of Type III construction, shall be of noncombustible material or not less than Schedule 40 plastic pipe.

16.3 WEATHER PROTECTION

16.3.1 General.
Roof decks shall be covered with approved roof coverings secured to the building or structure in accordance with the provisions of this part. Roof coverings shall be designed in accordance with this Code, and installed in accordance with this Code and the manufacturer’s approved instructions.

16.3.2 Flashing.
Flashing shall be installed in such a manner so as to prevent water from entering the wall and roof through joints in copings, through moisture-permeable materials and at interclauses with parapet walls and other penetrations through the roof plane.

16.3.2.1 Locations.
Flashing shall be installed at wall and roof interclauses, at gutters, wherever there is a change in roof slope or direction and around roof openings. Where flashing is of metal, the metal shall be corrosion resistant with a thickness of not less than 0.483 mm (0.019 inch) (No. 26 galvanized sheet).

16.3.3 Coping.
Parapet walls shall be properly coped with noncombustible, weatherproof materials of a width not less than the thickness of the parapet wall.

16.3.4 Attic and rafter ventilation.
Intake and exhaust vents shall be provided in accordance with Clause 13.2.2 and the vent product manufacturer’s installation instructions.

16.3.5 Crickets and saddles.
A cricket or saddle shall be installed on the ridge side of any chimney or penetration.
greater than 762 mm (30 inches) wide as measured perpendicular to the slope. Cricket or saddle coverings shall be sheet metal or of the same material as the roof covering.

Exception: Unit skylights installed in accordance with Clause 25.5.5 and flashed in accordance with the manufacturer’s instructions shall be permitted to be installed without a cricket or saddle.

16.4 PERFORMANCE REQUIREMENTS

16.4.1 Wind resistance of roofs.

Roof decks and roof coverings shall be designed for wind loads in accordance with Part 16 and Clauses 16.4.2, 16.4.3 and 16.4.4.

16.4.1.1 Wind resistance of asphalt shingles.

Asphalt shingles shall be tested in accordance with ASTM D7158. Asphalt shingles shall meet the classification requirements of Part 17 (Structural loads and Design) for the appropriate maximum basic wind speed. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D7158.

16.4.2 Wind resistance of clay and concrete tile.

Wind loads on clay and concrete tile roof coverings shall be in accordance with this Code.

16.4.2.1 Testing.

Testing of concrete and clay roof tiles shall be in accordance with Clauses 16.4.2.1.1 and 16.4.2.1.2.

16.4.2.1.1 Overturning resistance.

Concrete and clay roof tiles shall be tested to determine their resistance to overturning due to wind in accordance with Part 15 and either ASTM C1568.

16.4.2.1.2 Wind tunnel testing.

Where concrete and clay roof tiles do not satisfy the limitations in Part 16 for rigid tile, a wind tunnel test shall be used to determine the wind characteristics of the concrete or clay tile roof covering in accordance with ASTM C1568 and Part 15.

16.4.3 Wind resistance of nonballasted roofs.

Roof coverings installed on roofs in accordance with Clause 16.7 that are mechanically attached or adhered to the roof deck shall be designed to resist the design wind load pressures for components and cladding in accordance with this Code. The wind load on the roof covering shall be permitted to be determined using allowable stress design.

16.4.3.1 Other roof systems.

Built-up, modified bitumen, fully adhered or mechanically attached single-ply roof systems, metal panel roof systems applied to a solid or closely fitted deck and other types of membrane roof coverings shall be tested in accordance with this Code.

16.4.3.2 Structural metal panel roof systems.

Where the metal roof panel functions as the roof deck and roof covering and it provides both weather protection and support for loads, the structural metal panel roof system shall comply with this clause. Structural standing-seam metal panel roof systems shall be tested in accordance with ASTM E1592. Structural through-fastened metal panel roof systems shall be tested in accordance with ASTM E1592.

Exceptions:

1. Metal roofs constructed of cold-formed steel shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in this Code.

2. Metal roofs constructed of aluminum shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in this Code.

16.4.3.3 Metal roof shingles.

Metal roof shingles applied to a solid or closely fitted deck shall be tested in accordance with ASTM D3161. Metal roof shingles tested in
accordance with ASTM D3161 shall meet the classification requirements of Table 16.4.1.1 for the appropriate maximum basic wind speed and the metal shingle packaging shall bear a label to indicate compliance with ASTM D3161 and the required classification in Table 16.4.1.1.

16.4.4 Ballasted low-slope roof systems.
Ballasted low-slope (roof slope < 2:12) single-ply roof system coverings installed in accordance with Clauses 16.7.12 and 16.7.13 shall be designed in accordance with Clause 16.4.8.

16.4.5 Edge securement for low-slope roofs.
Low-slope built-up, modified bitumen and single-ply roof system metal edge securement, except gutters, shall be designed and installed for wind loads in accordance with Part 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except basic design wind speed, V, shall be determined from this Code through 1609.3(8) as applicable.

16.4.6 Physical properties.
Roof coverings installed on low-slope roofs (roof slope < 2:12) in accordance with Clause 1507 shall demonstrate physical integrity over the working life of the roof based on 2,000 hours of exposure to accelerated weathering tests conducted in accordance with ASTM G152, ASTM G154 or ASTM G155. Those roof coverings that are subject to cyclical flexural response due to wind loads shall not demonstrate any significant loss of tensile strength for unreinforced membranes or breaking strength for reinforced membranes when tested as herein required.

16.4.7 Impact resistance.
Roof coverings installed on low-slope roofs (roof slope < 2:12) in accordance with Clause 1507 shall resist impact damage based on the results of tests conducted in accordance with ASTM D3746, ASTM D4272 or the “Resistance to Foot Traffic Test”.

16.5 FIRE CLASSIFICATION

16.5.1 General.
Roof assemblies shall be divided into the classes defined in this clause. Class A, B and C roof assemblies and roof coverings required to be listed by this clause shall be tested in accordance with ASTM E108. In addition, fire-retardant-treated wood roof coverings shall be tested in accordance with ASTM D2898. The minimum roof coverings installed on buildings shall comply with Table 16.5.1 based on the type of construction of the building.

Exception: Skylights and sloped glazing that comply with Part 25 or clause 27.10.

16.5.2 Class A roof assemblies.
Class A roof assemblies are those that are effective against severe fire test exposure. Class A roof assemblies and roof coverings shall be listed and identified as Class A by an approved testing agency. Class A roof assemblies shall be permitted for use in buildings or structures of all types of construction.

Exceptions:

1. Class A roof assemblies include those with coverings of brick, masonry or an exposed concrete roof deck.

2. Class A roof assemblies also include ferrous or copper shingles or sheets, metal sheets and shingles, clay or concrete roof tile or slate installed on noncombustible decks or ferrous, copper or metal sheets installed without a roof deck on noncombustible framing.

3. Class A roof assemblies include minimum 0.0479 kN/m² (16 ounce per square foot) copper sheets installed over combustible decks.

4. Class A roof assemblies include slate installed over ASTM D226, Type II underlayment over combustible decks.
16.5.3 Class B roof assemblies.  
Class B roof assemblies are those that are effective against moderate fire-test exposure. Class B roof assemblies and roof coverings shall be listed and identified as Class B by an approved testing agency.

16.5.4 Class C roof assemblies.  
Class C roof assemblies are those that are effective against light fire-test exposure. Class C roof assemblies and roof coverings shall be listed and identified as Class C by an approved testing agency.

16.5.5 Nonclassified roofing.  
Nonclassified roofing is approved material that is not listed as a Class A, B or C roof covering.

16.5.6 Fire-retardant-treated wood shingles and shakes.  
Fire-retardant-treated wood shakes and shingles shall be treated by impregnation with chemicals by the full-cell vacuum-pressure process, in accordance with GS 146. Each bundle shall be marked to identify the manufacturer and the manufacturer, and shall be labeled to identify the classification of the material in accordance with the testing required in Clause 16.5.1, the treating company and the quality control agency.

16.5.7 Special purpose roofs.  
Special purpose wood shingle or wood shake roofing shall conform to the grading and application requirements of Clause 16.7.8 or 16.7.9. In addition, an underlayment of 15.9 mm (5/8-inch) Type X water-resistant gypsum backing board or gypsum sheathing shall be placed under minimum nominal 12.7 mm-thick 1/2 inch) wood structural panel solid sheathing or 25 mm (1-inch) nominal spaced sheathing.

16.5.8 Building-integrated photovoltaic products.  
Building-integrated photovoltaic products installed as the roof covering shall be tested, listed and identified for fire classification in accordance with Clause 16.5.1.

16.5.9 Rooftop mounted photovoltaic panel systems.  
Rooftop rack-mounted photovoltaic panel systems shall be tested, listed and identified with a fire classification in accordance with IEC 61730. The fire classification shall comply with Table 16.5.1 based on the type of construction of the building.

16.5.10 Roof gardens and landscaped roofs.  
Roof gardens and landscaped roofs shall comply with Clause 16.5.1 and 16.7.16 and shall be installed in accordance with this Code.

16.6 MATERIALS

16.6.1 Scope.  
The requirements set forth in this clause shall apply to the application of roof-covering materials specified herein. Roof coverings shall be applied in accordance with this part and the manufacturer’s installation instructions. Installation of roof coverings shall comply with the applicable provisions of Clause 16.7.

16.6.2 Material specifications and physical characteristics.  
Roof-covering materials shall conform to the applicable standards listed in this part.
16.6.3 Product identification.

Roof-covering materials shall be delivered in packages bearing the manufacturer's identifying marks and approved testing agency labels required in accordance with Clause 16.5. Bulk shipments of materials shall be accompanied with the same information issued in the form of a certificate or on a bill of lading by the manufacturer.

16.7 REQUIREMENTS FOR ROOF COVERINGS

16.7.1 Scope.

Roof coverings shall be applied in accordance with the applicable provisions of this clause and the manufacturer’s installation instructions.

16.7.1.1 Underlayment.

Underlayment for asphalt shingles, clay and concrete tile, metal roof shingles, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles, wood shakes, metal roof panels and photovoltaic shingles shall conform to the applicable standards listed in this part. Underlayment materials required to comply with ASTM D226, D1970, D4869 and D6757 shall bear a label indicating compliance with the standard designation and, if applicable, type classification indicated in Table 16.7.1.1(1). Underlayment shall be applied in accordance with Table 16.7.1.1(2). Underlayment shall be attached in accordance with Table 16.7.1.1(3).

Exceptions:

1. As an alternative, self-adhering polymer modified bitumen underlayment complying with ASTM D1970 and installed in accordance with the manufacturer’s installation instructions for the deck material, roof ventilation configuration and climate exposure for the roof covering to be installed shall be permitted.

2. As an alternative, a minimum 102 mm-wide (4-inch) strip of self-adhering polymer modified bitumen membrane complying with ASTM D1970 and installed in accordance with the manufacturer’s installation instructions for the deck material shall be applied over all joints in the roof decking. An approved underlayment for the applicable roof covering for design wind speeds less than 54 m/s (120 mph) shall be applied over the 102 mm-wide (4-inch) membrane strips.

3. As an alternative, two layers of underlayment complying with ASTM D226 Type I or ASTM D4869 Type III shall be permitted to be installed as follows: Apply a 19-inch (483 mm) strip of underlayment parallel with the eave. Starting at the eave, apply 36-inch-wide (914 mm) strips of underlayment felt, overlapping successive 483 mm sheets (19 inches). The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 305 mm (12 inches) between side laps with a 6-inch (152 mm) spacing at side and end laps. End laps shall be 102 mm (4 inches) and shall be offset by 1829 mm (6 feet). Underlayment shall be attached using metal or plastic cap nails with a nominal cap diameter of not less than 25.4 mm (1 inch). Metal caps shall have a thickness of not less than 32-gage sheet metal. Power-driven metal caps shall have a thickness of not less than 0.010 inch (mm). Thickness of the outside edge of plastic caps shall be not less than 0.035 inch (mm). The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch (mm) for smooth shank cap nails. The cap nail shank shall have a length sufficient to penetrate through the roof sheathing or not less than 19.1 mm (3/4 inch) into the roof sheathing.

4. Structural metal panels that do not require a substrate or underlayment.
### Table 16.7.1.1(1) Underlayment Types

<table>
<thead>
<tr>
<th>Roof Covering</th>
<th>Clause</th>
<th>Maximum Basic Design Wind Speed, V &lt; 140 MPH</th>
<th>Maximum Basic Design Wind Speed, V &gt; 140 MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt shingles</td>
<td>16.7.2</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type I or II</td>
<td>ASTM D4869 Type II</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D6757</td>
<td>ASTM D6757</td>
</tr>
<tr>
<td>Clay and concrete tiles</td>
<td>16.7.3</td>
<td>ASTM D2626 Type I</td>
<td>ASTM D2626 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D6380 Class M</td>
<td>ASTM D6380 Class M</td>
</tr>
<tr>
<td>Metal panels</td>
<td>16.7.4</td>
<td>Manufacturer’s instructions</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ASTM D4869 Type III</td>
</tr>
<tr>
<td>Metal roof shingles</td>
<td>16.7.5</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type I or II</td>
<td>ASTM D4869 Type II</td>
</tr>
<tr>
<td>Mineral-surfaced roll roofing</td>
<td>16.7.6</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type I or II</td>
<td>ASTM D4869 Type II</td>
</tr>
<tr>
<td>Slate shingles</td>
<td>16.7.7</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type II or III</td>
<td>ASTM D4869 Type III</td>
</tr>
<tr>
<td>Wood shingles</td>
<td>16.7.8</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type I, II or III</td>
<td>ASTM D4869 Type III</td>
</tr>
<tr>
<td>Wood shakes</td>
<td>16.7.9</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type I, II or III</td>
<td>ASTM D4869 Type III</td>
</tr>
<tr>
<td>Photovoltaic shingles</td>
<td>16.7.17</td>
<td>ASTM D226 Type I</td>
<td>ASTM D226 Type I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D4869 Type I, II or III</td>
<td>ASTM D4869 Type III</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D6757</td>
<td>ASTM D6757</td>
</tr>
</tbody>
</table>
### TABLE 16.7.1.1(2) UNDERLAYMENT APPLICATION

<table>
<thead>
<tr>
<th>ROOF COVERING</th>
<th>SECTION</th>
<th>MAXIMUM BASIC DESIGN WIND SPEED, $V &lt; 140$ MPH</th>
<th>MAXIMUM BASIC DESIGN WIND SPEED, $V &lt; 140$ MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt shingles</td>
<td>1507.2</td>
<td>For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied as follows: Apply a 19-inch strip of underlayment (cut parallel) to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of underlayment, overlapping successive sheets 19 inches. End laps shall be 4 inches and shall be offset by 6 feet. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied as follows: Underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet.</td>
<td>Same as Maximum Basic Design Wind Speed. $V &lt; 140$ mph except all laps shall be not less than 4 inches</td>
</tr>
<tr>
<td>Clay and concrete tile</td>
<td>1507.3</td>
<td>For roof slopes from two and one-half units vertical in 12 units horizontal ($2\frac{1}{2}:12$), up to four units vertical in 12 units horizontal (4:12), underlayment shall be not fewer than two layers applied as follows: Starting at the eave, a 19-inch strip of underlayment shall be applied parallel with the eave. Starting at the eave, a 36-inch-wide strip of underlayment felt shall be applied, overlapping successive sheets 19 inches. End laps shall be 4 inches and shall be offset by 6 feet. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied as follows: Underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches. End laps shall be 4 inches and shall be offset by 6 feet.</td>
<td>Same as Maximum Basic Design Wind Speed. $V &lt; 140$ mph except all laps shall be not less than 4 inches</td>
</tr>
<tr>
<td>Metal roof panels</td>
<td>1507.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal roof shingles</td>
<td>1507.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral-faced roll roofing</td>
<td>1507.6</td>
<td>Apply in accordance with the manufacturer’s installation instructions</td>
<td></td>
</tr>
<tr>
<td>Slate shingles</td>
<td>1507.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood shakes</td>
<td>1507.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood shingles</td>
<td>1507.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>1207.17</td>
<td>For roof slopes from three units vertical in 12 units horizontal (3:12), up to four units vertical in 12 units horizontal (4:12), underlayment shall be two layers applied as follows: Apply a 19-inch strip of underlayment (cut parallel) to and starting at the eaves. Starting at the eave, apply 36-inch wide sheets of underlayment, overlapping successive sheets 19 inches. End laps shall be 4 inches and shall be offset by 6 feet. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, underlayment shall be one layer applied as follows: Underlayment shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches. Distortions in the underlayment shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet.</td>
<td>Same as Maximum Basic Design Wind Speed. $V &lt; 140$ mph except all laps shall be not less than 4 inches</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm; 1 mile per hour = 0.447 m/s.
## TABLE 16.7.1.1(3): UNDERLAYMENT ATTACHMENT

<table>
<thead>
<tr>
<th>ROOF COVERING</th>
<th>CLAUSE</th>
<th>MAXIMUM BASIC DESIGN WIND SPEED, $V &lt; 140$ MPH</th>
<th>MAXIMUM BASIC DESIGN WIND SPEED, $V \geq 140$ MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt shingles</td>
<td>16.7.2</td>
<td></td>
<td>The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches between side laps with a 6-inch spacing at side and end laps. Underlayment shall be attached using metal or plastic cap nails or cap staples with a nominal cap diameter of not less than 1 inch. Metal caps shall have a thickness of not less than 32-gage (0.0134 inch) sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch for smooth shank cap nails. Staples shall be not less than 21 gage (0.032 inch). The cap nail shank and cap staple legs shall have a length sufficient to penetrate through the roof sheathing or not less than 3/4 inch into the roof sheathing.</td>
</tr>
<tr>
<td>Clay and concrete tile</td>
<td>16.7.3</td>
<td>Fastened sufficiently to hold in place</td>
<td></td>
</tr>
<tr>
<td>Photovoltaic shingles</td>
<td>16.7.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal roof panels</td>
<td>16.7.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal roof shingles</td>
<td>16.7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral surfaced roll roofing</td>
<td>16.7.6</td>
<td>Manufacturer’s installation instruction</td>
<td>The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches between side laps with a 6-inch spacing at side and end laps. Underlayment shall be attached using metal or plastic cap nails or cap staples with a nominal cap diameter of not less than 1 inch. Metal caps shall have a thickness of not less than 32-gage sheet metal. Power-driven metal caps shall have a minimum thickness of 0.010 inch. Minimum thickness of the outside edge of plastic caps shall be 0.035 inch. The cap nail shank shall be not less than 0.083 inch for ring shank cap nails and 0.091 inch for smooth shank cap nails. Staples shall be not less than 21 gage (0.032 inch). The cap nail shank and cap staple legs shall have a length sufficient to penetrate through the roof sheathing or not less than 3/4 inch into the roof sheathing.</td>
</tr>
<tr>
<td>Slate shingles</td>
<td>16.7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood shingles</td>
<td>16.7.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood shakes</td>
<td>16.7.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm; 1 mile per hour = 0.447 m/s.

**Exception:** Detached accessory structures that do not contain conditioned floor area.

### 16.7.2 Asphalt shingles.

The installation of asphalt shingles shall comply with the provisions of this clause.

#### 16.7.2.1 Deck requirements.

Asphalt shingles shall be fastened to solidly sheathed decks.

#### 16.7.2.2 Slope.

Asphalt shingles shall only be used on roof slopes of two units vertical in 12 units horizontal (17-percent slope) or greater. For roof slopes from two units vertical in 12 units horizontal (17-percent slope) up to four units vertical in 12 units horizontal (33-percent slope), double underlayment application is required in accordance with Clause 16.7.2.8.

#### 16.7.2.3 Underlayment.

Underlayment shall comply with Clause 16.7.1.1.

#### 16.7.2.4 Asphalt shingles.

Asphalt shingles shall comply with ASTM D3462.
16.7.2.5 Fasteners.

Fasteners for asphalt shingles shall be galvanized, stainless steel, aluminum or copper roofing nails, minimum 12-gage [2.67 mm (0.105 inch)] shank with a minimum 9.5 mm (\(\frac{3}{8}\) inch)-diameter head, of a length to penetrate through the roofing materials and not less than 19.1 mm (\(\frac{3}{4}\) inch) into the roof sheathing. Where the roof sheathing is less than 19.1 mm (\(\frac{3}{4}\) inch) thick, the nails shall penetrate through the sheathing. Fasteners shall comply with ASTM F1667.

16.7.2.6 Attachment.

Asphalt shingles shall have the minimum number of fasteners required by the manufacturer, but not less than four fasteners per strip shingle or two fasteners per individual shingle. Where the roof slope exceeds 21 units vertical in 12 units horizontal (21:12), shingles shall be installed as required by the manufacturer.

16.7.2.8 Flashings.

Flashings for asphalt shingles shall comply with this clause. Flashing shall be applied in accordance with this clause and the asphalt shingle manufacturer’s printed instructions.

16.7.2.8.1 Base and cap flashing.

Base and cap flashing shall be installed in accordance with the manufacturer’s instructions. Base flashing shall be of either corrosion-resistant metal of minimum nominal 0.483 mm (0.019-inch) thickness or mineral-surfaced roll roofing weighing not less than 77 pounds per 3.76 m\(^2\) (100 square feet). Cap flashing shall be corrosion-resistant metal of minimum nominal 0.483 mm (0.019-inch) thickness.

16.7.2.8.2 Valleys.

Valley linings shall be installed in accordance with the manufacturer’s instructions before applying shingles. Valley linings of the following types shall be permitted:

1. For open valleys (valley lining exposed) lined with metal, the valley lining shall not be less than 610 mm (24 inches) wide and of any of the corrosion-resistant metals in Table 16.7.2.8.2.

2. For open valleys, valley lining of two plies of mineral-surfaced roll roofing complying with ASTM D3909 or ASTM D6380 shall be permitted. The bottom layer shall be 457 mm (18 inches) and the top layer not less than 914 mm (36 inches) wide.

3. For closed valleys (valleys covered with shingles), valley lining of one ply of smooth roll roofing complying with ASTM D6380, and not less than 914 mm (36 inches) wide or types as described in Item 1 or 2 above shall be permitted. Self-adhering polymer modified bitumen underlayment bearing a label indicating compliance with ASTM D1970 shall be permitted in lieu of the lining material.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>MINIMUM THICKNESS</th>
<th>GAGE</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.024 in.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Cold-rolled copper</td>
<td>0.0216 in.</td>
<td>—</td>
<td>ASTM B370, 16 oz. per square ft.</td>
</tr>
<tr>
<td>Copper</td>
<td>—</td>
<td>26</td>
<td>16 oz</td>
</tr>
<tr>
<td>Galvanized steel</td>
<td>0.0179 in.</td>
<td>—</td>
<td>ASTM B370, 12 oz. per square ft.</td>
</tr>
<tr>
<td>High-yield copper</td>
<td>0.0162 in.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Painted terne</td>
<td>—</td>
<td>—</td>
<td>20 pounds</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>—</td>
<td>28</td>
<td>—</td>
</tr>
<tr>
<td>Zinc alloy</td>
<td>0.027 in.</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**NOTE:** For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg, 1 ounce = 28.35 g, 1 square foot = 0.0929 m\(^2\).
16.7.2.8.3 Drip edge.

A drip edge shall be provided at eaves and rake edges of shingle roofs. Adjacent segments of the drip edge shall be lapped not less than 51 mm (2 inches). The vertical leg of drip edges shall be not less than 38 mm (1 1/2 inches) in width and shall extend not less than 6.4 mm (1/4 inch) below sheathing. The drip edge shall extend back on the roof not less than 51 mm (2 inches). Underlayment shall be installed over drip edges along eaves. Drip edges shall be installed over underlayment along rake edges. Drip edges shall be mechanically fastened at intervals not greater than 305 mm (12 inches) on center.

16.7.3 Clay and concrete tile.

The installation of clay and concrete tile shall comply with the provisions of this clause.

16.7.3.1 Deck requirements.

Concrete and clay tile shall be installed only over solid sheathing or spaced structural sheathing boards.

16.7.3.2 Deck slope.

Clay and concrete roof tile shall be installed on roof slopes of 2 1/2 units vertical in 12 units horizontal (21-percent slope) or greater. For roof slopes from 2 1/2 units vertical in 12 units horizontal (21-percent slope) to four units vertical in 12 units horizontal (33-percent slope), double underlayment application is required in accordance with Clause 16.7.3.3.

16.7.3.3 Underlayment.

Unless otherwise noted, required underlayment shall conform to: ASTM D226, Type II; ASTM D2626 or ASTM D6380, Class M mineral-surfaced roll roofing.

16.7.3.4 Clay tile.

Clay roof tile shall comply with ASTM C1167.

16.7.3.5 Concrete tile.

Concrete roof tile shall comply with ASTM C1492.

16.7.3.6 Fasteners.

Tile fasteners shall be corrosion resistant and not less than 11-gage, 8.0 mm 5/16-inch head, and of sufficient length to penetrate the deck not less than 19.1 mm (3/4 inch) or through the thickness of the deck, whichever is less. Attaching wire for clay or concrete tile shall not be smaller than 2.1 mm (0.083 inch). Perimeter fastening areas include three tile courses but not less than 914 mm (36 inches) from either side of hips or ridges and edges of eaves and gable rakes.
16.7.3.3 Underlayment.
Unless otherwise noted, required underlayment shall conform to: ASTM D226, Type II; ASTM D2626 or ASTM D6380, Class M mineral-surfaced roll roofing.

16.7.3.4 Clay tile.
Clay roof tile shall comply with ASTM C1167.

16.7.3.5 Concrete tile.
Concrete roof tile shall comply with ASTM C1492.

16.7.3.6 Fasteners.
Tile fasteners shall be corrosion resistant and not less than 11-gage, 8.0 mm \( \frac{5}{16} \) inch head, and of sufficient length to penetrate the deck not less than 19.1 mm \( \frac{3}{4} \) inch or through the thickness of the deck, whichever is less. Attaching wire for clay or concrete tile shall not be smaller than 2.1 mm (0.083 inch). Perimeter fastening areas include three tile courses but not less than 914 mm (36 inches) from either side of hips or ridges and edges of eaves and gable rakes.

16.7.3.7 Attachment.
Clay and concrete roof tiles shall be fastened in accordance with Table 16.7.3.7.

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**TABLE 16.7.3.7: CLAY AND CONCRETE TILE ATTACHMENT**

<table>
<thead>
<tr>
<th>Maximum Allowable Stress Design Wind Speed, ( V_{16}^{\text{a}} ) (mph)</th>
<th>Mean roof height (feet)</th>
<th>General - Clay or Concrete Roof Tile</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>0-60</td>
<td>One fastener per tile. Flat tile without vertical laps, two fasteners per tile. Two fasteners per tile. Only one fastener on slopes of 7:12 and less for tiles with installed weight exceeding 7.5 lbs/sq. ft, having a width not more than 16 inches.</td>
</tr>
<tr>
<td>100</td>
<td>0-40</td>
<td>The head of all tiles shall be nailed. The nose of all eave tiles shall be fastened with approved clips. Rake tiles shall be nailed with two nails. The nose of all ridge, hip and rake tiles shall be set in a bead of roofer’s mastic.</td>
</tr>
<tr>
<td>100</td>
<td>&gt; 40-60</td>
<td>The nose of all eave tiles shall be fastened with approved clips. Rake tiles shall be nailed with two nails. The nose of all ridge, hip and rake tiles shall be set in a bead of roofer’s mastic.</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 4.882 kg/m².

a. Minimum fastener size. Corrosion-resistant nails not less than No. 11 gage with \( \frac{3}{4} \) inch head. Fasteners shall be long enough to penetrate into the sheathing \( \frac{5}{16} \) inch or through the thickness of the sheathing, whichever is less. Attaching wire for clay and concrete tile shall not be smaller than 0.083 inch.
b. Snow areas. Not fewer than two fasteners per tile are required or battens and one fastener.

c. Roof slopes greater than 24:12. The nose of all tiles shall be securely fastened.

d. Horizontal battens. Battens shall be not less than 1 inch by 2 inch nominal. Provisions shall be made for drainage by a riser of not less than 1/8 inch at each nail or by 4-foot-long battens with not less than a 1/8-inch separation between battens.

Horizontal battens are required for slopes over 7:12.

e. Perimeter fastening areas include three tile courses but not less than 36 inches from either side of hips or ridges and edges of eaves and gable rakes.

f. \( \frac{V}{S} \) shall be determined in accordance with this Code.

### 16.7.3.8 Application.

Tile shall be applied according to the manufacturer’s installation instructions, based on the following:

1. Climatic conditions.
2. Roof slope.
3. Underlayment system.
4. Type of tile being installed.

### 16.7.3.9 Flashing.

At the juncture of the roof vertical surfaces, flashing and counterflashing shall be provided in accordance with the manufacturer’s installation instructions, and where of metal, shall be not less than 0.48 mm (0.019-inch) (No. 26 galvanized sheet gage) corrosion-resistant metal. The valley flashing shall extend not less than 279 mm (11 inches) from the centerline each way and have a splash diverter rib not less than 25 mm (1 inch) high at the flow line formed as part of the flashing. Clauses of flashing shall have an end lap of not less than 102 mm (4 inches). For roof slopes of three units vertical in 12 units horizontal (25-percent slope) and over, the valley flashing shall have a 914 mm (36-inch-wide) underlayment of either one layer of Type I underlayment running the full length of the valley, or a self-adhering polymer-modified bitumen sheet bearing a label indicating compliance with ASTM D1970, in addition to other required underlayment. In areas where the average daily temperature in January is -4°C (25°F) or less or where there is a possibility of ice forming along the eaves causing a backup of water, the metal valley flashing underlayment shall be solid cemented to the roofing underlayment for slopes under seven units vertical in 12 units horizontal (58-percent slope) or self-adhering polymer-modified bitumen sheet shall be installed.

### 16.7.4 Metal roof panels.

The installation of metal roof panels shall comply with the provisions of this clause.

### 16.7.4.1 Deck requirements.

Metal roof panel roof coverings shall be applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied to spaced supports.

### 16.7.4.2 Deck slope.

Minimum slopes for metal roof panels shall comply with the following:

1. The minimum slope for lapped, nonsoldered seam metal roof panels without applied lap sealant shall be three units vertical in 12 units horizontal (25-percent slope).

2. The minimum slope for lapped, nonsoldered seam metal roof panels with applied lap sealant shall be one-half unit vertical in 12 units horizontal (4-percent slope). Lap sealants shall be applied in accordance with the approved manufacturer’s installation instructions.

3. The minimum slope for standing-seam metal roof panel systems shall be one-quarter unit vertical in 12 units horizontal (2-percent slope).

### 16.7.4.3 Material standards.

Metal-sheet roof covering systems that incorporate supporting structural members shall be designed in accordance with Part 22. Metal-sheet roof coverings installed over structural decking shall comply with Table 16.7.4.3(1). The materials used for metal-sheet roof coverings shall be naturally corrosion resistant or provided with corrosion resistance in accordance with the standards and minimum thicknesses shown in Table 16.7.4.3(2).

#### TABLE 16.7.4.3(1): METAL ROOF COVERINGS

<table>
<thead>
<tr>
<th>ROOF COVERING TYPE</th>
<th>STANDARD APPLICATION RATE/THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>ASTM B209, 0.024 inch minimum thickness for roll-formed panels and 0.019</td>
</tr>
</tbody>
</table>

521
### Inch Minimum Thickness for Press-Formed Shingles

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum-zinc alloy coated steel</td>
<td>ASTM A792 AZ 50</td>
</tr>
<tr>
<td>Cold-rolled copper</td>
<td>ASTM B370 minimum 16 oz./sq. ft. and 12 oz./sq. ft. high yield copper for metal-sheet roof covering systems: 12 oz./sq. ft. for preformed metal shingle systems</td>
</tr>
<tr>
<td>Copper</td>
<td>16 oz./sq. ft. for metal-sheet roof-covering systems; 12 oz./sq. ft. for preformed metal shingle systems</td>
</tr>
<tr>
<td>Prepainted steel</td>
<td>ASTM A755</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>ASTM A240, 300 Series Alloys</td>
</tr>
<tr>
<td>Steel</td>
<td>ASTM A924</td>
</tr>
<tr>
<td>Terne and terne coated stainless</td>
<td>Terne coating of 40 lbs. per double base box, field painted where applicable in accordance with manufacturer’s installation instructions.</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.027 inch minimum thickness; 99.995% electrolytic high grade zinc with alloy additives of copper (0.08% - 0.20%), titanium (0.07% - 0.12%) and aluminum (0.015%).</td>
</tr>
</tbody>
</table>

### Note
- For SI: 1 ounce per square foot = 0.305 kg/m², 1 pound per square foot = 4.882 kg/m², 1 inch = 25.4 mm, 1 pound = 0.454 kg.
- For Group U buildings, the minimum coating thickness for ASTM A653 galvanized steel roofing shall be G-60.

### TABLE 16.7.4.3(2): Minimum Corrosion Resistance

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>55% Aluminum-zinc alloy coated steel</td>
<td>ASTM A792 AZ 50</td>
</tr>
<tr>
<td>5% Aluminum alloy-coated steel</td>
<td>ASTM A875 GF60</td>
</tr>
<tr>
<td>Aluminum-coated steel</td>
<td>ASTM A463 T2 65</td>
</tr>
<tr>
<td>Galvanized steel</td>
<td>ASTM A653 G-90</td>
</tr>
</tbody>
</table>

### 16.7.4.4 Attachment.
Metal roof panels shall be secured to the supports in accordance with the approved manufacturer’s fasteners. In the absence of manufacturer recommendations, the following fasteners shall be used:

1. Galvanized fasteners shall be used for steel roofs.
2. Copper, brass, bronze, copper alloy or 300 series stainless-steel fasteners shall be used for copper roofs.
3. Stainless-steel fasteners are acceptable for all types of metal roofs.
4. Aluminum fasteners are acceptable for aluminum roofs attached to aluminum supports.

### 16.7.4.5 Underlayment and High Wind.
Underlayment shall comply with Clause 16.7.1.1.

### 16.7.5 Metal Roof Shingles.
The installation of metal roof shingles shall comply with the provisions of this clause.

#### 16.7.5.1 Deck Requirements.
Metal roof shingles shall be applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied to spaced sheathing.

#### 16.7.5.2 Deck Slope.
Metal roof shingles shall not be installed on roof slopes below three units vertical in 12 units horizontal (25-percent slope).

#### 16.7.5.3 Underlayment.
Underlayment shall comply with Clause 16.7.1.1.

#### 16.7.5.5 Material Standards.
Metal roof shingle roof coverings shall comply with Table 16.7.4.3(1). The materials used for metal-roof shingle roof coverings shall be naturally corrosion resistant or provided with...
corrosion resistance in accordance with the standards and minimum thicknesses specified in the standards listed in Table 16.7.4.3(2).

16.7.5.6 Attachment.
Metal roof shingles shall be secured to the roof in accordance with the approved manufacturer’s installation instructions.

16.7.5.7 Flashing.
Roof valley flashing shall be of corrosion-resistant metal of the same material as the roof covering or shall comply with the standards in Table 16.7.4.3(1). The valley flashing shall extend not less than 203 mm (8 inches) from the centerline each way and shall have a splash diverter rib not less than 19.1 mm ( 3/4 inch) high at the flow line formed as part of the flashing. Clauses of flashing shall have an end lap of not less than 102 mm (4 inches). In areas where the average daily temperature in January is -4°C (25°F) or less or where there is a possibility of ice forming along the eaves causing a backup of water, the metal valley flashing shall have a 914 mm (36-inch-wide) underlayment directly under it consisting of either one layer of underlayment running the full length of the valley or a self-adhering polymer-modified bitumen sheet bearing a label indicating compliance with ASTM D1970, in addition to underlayment required for metal roof shingles. The metal valley flashing underlayment shall be solidly cemented to the roofing underlayment for roof slopes under seven units vertical in 12 units horizontal (58-percent slope) or self-adhering polymer-modified bitumen sheet shall be installed.

16.7.6 Mineral-surfaced roll roofing.
The installation of mineral-surfaced roll roofing shall comply with this clause.

16.7.6.1 Deck requirements.
Mineral-surfaced roll roofing shall be fastened to solidly sheathed roofs.

16.7.6.2 Deck slope.
Mineral-surfaced roll roofing shall not be applied on roof slopes below one unit vertical in 12 units horizontal (8-percent slope).

16.7.6.3 Underlayment.
Underlayment shall comply with Clause 16.7.1.1.

16.7.6.5 Material standards.
Mineral-surfaced roll roofing shall conform to ASTM D3909 or ASTM D6380.

16.7.7 Slate shingles.
The installation of slate shingles shall comply with the provisions of this clause.

16.7.7.1 Deck requirements.
Slate shingles shall be fastened to solidly sheathed roofs.

16.7.7.2 Deck slope.
Slate shingles shall only be used on slopes of four units vertical in 12 units horizontal (4:12) or greater.

16.7.7.3 Underlayment.
Underlayment shall comply with Clause 16.7.1.1.

16.7.7.5 Material standards.
Slate shingles shall comply with ASTM C406.

16.7.7.6 Application.
Minimum headlap for slate shingles shall be in accordance with Table 16.7.7.6. Slate shingles shall be secured to the roof with two fasteners per slate.

**TABLE 16.7.7.6: SLATE SHINGLE HEADLAP**

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>HEADLAP (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:12 &lt; slope &lt; 8:12</td>
<td>4</td>
</tr>
<tr>
<td>8:12 &lt; slope &lt; 20:12</td>
<td>3</td>
</tr>
<tr>
<td>slope ≥ 20:12</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

16.7.7.7 Flashing.
Flashing and counter flashing shall be made with sheet metal. Valley flashing shall be not less than 381 mm (15 inches) wide. Valley and flashing metal shall be a minimum uncoated thickness of 0.455 mm (0.0179-inch) zinc-coated G90. Chimneys, stucco or brick walls shall have not fewer than two plies of felt for a cap flashing consisting of a 102 mm -wide (4-inch) strip of felt set in plastic cement and extending 25 mm (1 inch) above the first felt and a top coating of plastic cement. The felt shall extend over the base flashing 51 mm (2 inches).

16.7.8 Wood shingles.
The installation of wood shingles shall comply with the provisions of this clause and Table 16.7.8.
TABLE 16.7.8: WOOD SHINGLE AND SHAKE INSTALLATION

<table>
<thead>
<tr>
<th>ROOF ITEM</th>
<th>WOOD SHINGLES</th>
<th>WOOD SHAKES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Roof slope</td>
<td>Wood shingles shall be installed on slopes of not less than three units vertical in 12 units horizontal (3:12).</td>
<td>Wood shingles shall be installed on slopes of not less than four units vertical in 12 units horizontal (4:12).</td>
</tr>
<tr>
<td>2. Deck requirement</td>
<td>Shingles shall be applied to roofs with solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 1&quot; x 4&quot; nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners.</td>
<td>Shakes shall be applied to roofs with solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 1&quot; x 4&quot; nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners. Where 1&quot; x 4&quot; spaced sheathing is installed at 10 inches, boards must be installed between the sheathing boards.</td>
</tr>
<tr>
<td>Temperate climate</td>
<td>Solid sheathing is required.</td>
<td>Solid sheathing is required.</td>
</tr>
<tr>
<td>In areas where the average daily temperature in January is 25°F or less or where there is a possibility of ice forming along the eaves causing a backup of water.</td>
<td>Solid sheathing is required.</td>
<td>Solid sheathing is required.</td>
</tr>
<tr>
<td>3. Underlayerment</td>
<td>No requirements.</td>
<td>Interlayerment shall comply with ASTM D226, Type 1.</td>
</tr>
<tr>
<td>4. Application</td>
<td>Underlayerment shall comply with Section 1507.1.1.</td>
<td>Underlayerment shall comply with Section 1507.1.1.</td>
</tr>
<tr>
<td>5. Application</td>
<td>Fasteners for wood shingles shall be hot-dipped galvanized or Type 904 (Type 316 for coastal areas) stainless steel with a minimum penetration of 0.75 inch into the sheathing. For sheathing less than 0.5 inch thick, the fasteners shall extend through the sheathing.</td>
<td>Fasteners for wood shakes shall be hot-dipped galvanized or Type 904 (Type 316 for coastal areas) stainless steel with a minimum penetration of 0.75 inch into the sheathing. For sheathing less than 0.5 inch thick, the fasteners shall extend through the sheathing.</td>
</tr>
<tr>
<td>No. of fasteners</td>
<td>Two per shingle.</td>
<td>Two per shake.</td>
</tr>
<tr>
<td>Exposure</td>
<td>Weather exposures shall not exceed those set forth in Table 1507.8.7.</td>
<td>Weather exposures shall not exceed those set forth in Table 1507.9.8.</td>
</tr>
<tr>
<td>Method</td>
<td>Shingles shall be laid with a side lap of not less than 1.5 inches between joints in courses, and no two joints in any three adjacent courses shall be in direct alignment. Spacing between shingles shall be 0.25 to 0.375 inch.</td>
<td>Shakes shall be laid with a side lap of not less than 1.5 inches between joints in adjacent courses. Spacing between shakes shall not be less than 0.375 inch or more than 0.625 inch for shakes and taper sawn shakes of naturally durable wood and shall be 0.25 to 0.375 inch for preservative-treated taper sawn shakes.</td>
</tr>
<tr>
<td>Flashing</td>
<td>In accordance with Section 1507.8.8.</td>
<td>In accordance with Section 1507.9.9.</td>
</tr>
</tbody>
</table>

16.7.8.1 Deck requirements.
Wood shingles shall be installed on solid or spaced sheathing. Where spaced sheathing is used, sheathing boards shall be not less than 25 mm by 102 mm (1-inch by 4-inch) nominal dimensions and shall be spaced on centers equal to the weather exposure to coincide with the placement of fasteners.

16.7.8.1.1 Solid sheathing.
Solid sheathing is required for the laying of wood shingles.

16.7.8.2 Deck slope.
Wood shingles shall be installed on slopes of not less than three units vertical in 12 units horizontal (25-percent slope).

16.7.8.3 Underlayerment.
Underlayerment shall comply with Clause 16.7.1.1.

16.7.8.5 Material standards.
Wood shingles shall be of naturally durable wood and comply with the requirements of Table 16.7.8.5.

TABLE 16.7.8.5: WOOD SHINGLE MATERIAL REQUIREMENTS (TO BE IN ACCORDANCE WITH GS)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>APPLICABLE MINIMUM GRADES</th>
<th>GRADING RULES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood shingles of naturally durable wood</td>
<td>1, 2 or 3</td>
<td>CSSB</td>
</tr>
</tbody>
</table>

Note: CSSB = Cedar Shake and Shingle Bureau.

Note: For SI: 1 inch = 25.4 mm, °C = [(°F) - 32]/1.8.
16.7.8.6 Attachment.
Fasteners for wood shingles shall be corrosion resistant with a minimum penetration of 19.1 mm (\(\frac{3}{4}\) inch) into the sheathing. For sheathing less than 12.7 mm (\(\frac{1}{2}\) inch) in thickness, the fasteners shall extend through the sheathing. Each shingle shall be attached with not fewer than two fasteners.

16.7.8.7 Application.
Wood shingles shall be laid with a side lap not less than 38 mm (1\(\frac{1}{2}\) inches) between joints in adjacent courses, and not be in direct alignment in alternate courses. Spacing between shingles shall be 6.4 to 9.5 mm (\(\frac{1}{4}\) to \(\frac{3}{8}\) inch). Weather exposure for wood shingles shall not exceed that set in Table 16.7.8.7.

<table>
<thead>
<tr>
<th>ROOFING MATERIAL</th>
<th>LENGTH (inches)</th>
<th>GRADE</th>
<th>EXPOSURE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>3:12 pitch to &lt; 4:12</td>
</tr>
<tr>
<td>Shingles of naturally durable wood</td>
<td>16</td>
<td>No. 1</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 2</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>No. 1</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 3</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>No. 1</td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 2</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 3</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.
16.7.8.8 Flashing.

At the juncture of the roof and vertical surfaces, flashing and counterflashing shall be provided in accordance with the manufacturer’s installation instructions, and where of metal, shall be not less than 0.48 mm (0.019-inch) (No. 26 galvanized sheet gage) corrosion-resistant metal. The valley flashing shall extend not less than 279 mm (11 inches) from the centerline each way and have a splash diverter rib not less than 25 mm (1 inch) high at the flow line formed as part of the flashing. Clauses of flashing shall have an end lap of not less than 102 mm (4 inches). For roof slopes of three units vertical in 12 units horizontal (25-percent slope) and over, the valley flashing shall have a 914 mm (36-inch) underlayment of either one layer of Type I underlayment running the full length of the valley or a self-adhering polymer-modified bitumen sheet bearing a label indicating compliance with ASTM D1970, in addition to other required underlayment.

16.7.8.9 Label required.

Each bundle of shingles shall be identified by a label of an approved grading or inspection bureau or agency.

16.7.10 Built-up roofs.

The installation of built-up roofs shall comply with the provisions of this clause.

16.7.10.1 Slope.

Built-up roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage, except for coal-tar built-up roofs that shall have a design slope of not less than one-eighth unit vertical in 12 units horizontal (1-percent slope).

16.7.10.2 Material standards.

Built-up roof covering materials shall comply with the standards in Table 16.7.10.2

<table>
<thead>
<tr>
<th>MATERIAL STANDARD</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic coatings used in roofing</td>
<td>ASTM D6083</td>
</tr>
<tr>
<td>Aggregate surfacing</td>
<td>ASTM D1863</td>
</tr>
<tr>
<td>Asphalt adhesive used in roofing</td>
<td>ASTM D3747</td>
</tr>
<tr>
<td>Asphalt cements used in roofing</td>
<td>ASTM D2822; D3019; D4586</td>
</tr>
<tr>
<td>Asphalt-coated glass fiber base sheet</td>
<td>ASTM D4601</td>
</tr>
<tr>
<td>Asphalt coatings used in roofing</td>
<td>ASTM D1227; D2823; D2824; D4479</td>
</tr>
<tr>
<td>Asphalt glass felt</td>
<td>ASTM D2178</td>
</tr>
<tr>
<td>Asphalt primer used in roofing</td>
<td>ASTM D41</td>
</tr>
<tr>
<td>Asphalt-saturated and asphalt-coated organic felt base sheet</td>
<td>ASTM D2626</td>
</tr>
<tr>
<td>Asphalt-saturated organic felt (perforated)</td>
<td>ASTM D226</td>
</tr>
<tr>
<td>Asphalt used in roofing</td>
<td>ASTM D312</td>
</tr>
<tr>
<td>Coal-tar cements used in roofing</td>
<td>ASTM D4022; D5643</td>
</tr>
<tr>
<td>Coal-tar saturated organic felt</td>
<td>ASTM D227</td>
</tr>
<tr>
<td>Coal-tar pitch used in roofing</td>
<td>ASTM D450; Type I</td>
</tr>
<tr>
<td>Coal-tar primer used in roofing, dampproofing and waterproofing</td>
<td>ASTM D43</td>
</tr>
<tr>
<td>Glass mat, coal tar</td>
<td>ASTM D4990</td>
</tr>
<tr>
<td>Mineral-surfaced inorganic cap sheet</td>
<td>ASTM D3909</td>
</tr>
<tr>
<td>Thermoplastic fabrics used in roofing</td>
<td>ASTM D5665; D5726</td>
</tr>
</tbody>
</table>

16.7.11 Modified bitumen roofing.

The installation of modified bitumen roofing shall comply with the provisions of this clause.

16.7.11.1 Slope.

Modified bitumen roofing shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

16.7.11.2 Material standards.

16.7.11.2.1 Base sheet.
A base sheet that complies with the requirements of Clause 16.7.11.2, ASTM D1970 or ASTM D4601 shall be permitted to be used with a modified bitumen cap sheet.

16.7.12 Thermoset single-ply roofing.
The installation of thermoset single-ply roofing shall comply with the provisions of this clause.

16.7.12.1 Slope.
Thermoset single-ply membrane roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

16.7.12.2 Material standards.
Thermoset single-ply roof coverings shall comply with ASTM D4637 or ASTM D5019.

16.7.12.3 Ballasted thermoset low-slope roofs.
Ballasted thermoset low-slope roofs (roof slope < 2:12) shall be installed in accordance with this clause and Clause 16.4.4. Stone used as ballast shall comply with ASTM D448 or ASTM D7655.

16.7.13 Thermoplastic single-ply roofing.
The installation of thermoplastic single-ply roofing shall comply with the provisions of this clause.

16.7.13.1 Slope.
Thermoplastic single-ply membrane roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope).

16.7.13.2 Material standards.
Thermoplastic single-ply roof coverings shall comply with ASTM D4434, ASTM D6754 or ASTM D6878.

16.7.13.3 Ballasted thermoplastic low-slope roofs.
Ballasted thermoplastic low-slope roofs (roof slope < 2:12) shall be installed in accordance with this clause and Clause 1504.4. Stone used as ballast shall comply with ASTM D448 or ASTM D7655.

16.7.14 Sprayed polyurethane foam roofing.
The installation of sprayed polyurethane foam roofing shall comply with the provisions of this clause.

16.7.14.1 Slope.
Sprayed polyurethane foam roofs shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) for drainage.

Spray-applied polyurethane foam insulation shall comply with ASTM C1029 Type II or III or ASTM D7425.

16.7.14.3 Application.
Foamed-in-place roof insulation shall be installed in accordance with the manufacturer's instructions. A liquid-applied protective coating that complies with Table 16.7.14.3 shall be applied not less than 2 hours nor more than 72 hours following the application of the foam.

| TABLE 16.7.14.3: PROTECTIVE COATING MATERIAL STANDARDS |
|----------------|----------------|
| MATERIAL         | STANDARD       |
| Acrylic coating  | ASTM D6083     |
| Silicone coating | ASTM D6694     |
| Moisture-cured polyurethane coating | ASTM D6947 |

16.7.14.4 Foam plastics.
Foam plastic materials and installation shall comply with Part 27.

16.7.15 Liquid-applied roofing.
The installation of liquid-applied roofing shall comply with the provisions of this clause.

16.7.15.1 Slope.
Liquid-applied roofing shall have a design slope of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope).

16.7.15.2 Material standards.
Liquid-applied roofing shall comply with ASTM C836, ASTM C957, ASTM D1227 or ASTM D3468, ASTM D6083, ASTM D6694 or ASTM D6947.
16.7.16 Vegetative roofs, roof gardens and landscaped roofs.
Vegetative roofs, roof gardens and landscaped roofs shall comply with the requirements of this part, and the Ghana Fire Code.

16.7.16.1 Structural fire resistance.
The structural frame and roof construction supporting the load imposed on the roof by the vegetative roof, roof gardens or landscaped roofs shall comply with the requirements of this Code.

16.7.17 Photovoltaic shingles.
The installation of photovoltaic shingles shall comply with the provisions of this clause.

16.7.17.1 Deck requirements.
Photovoltaic shingles shall be applied to a solid or closely fitted deck, except where the shingles are specifically designed to be applied over spaced sheathing.

16.7.17.2 Deck slope.
Photovoltaic shingles shall be installed on roof slopes of not less than two units vertical in 12 units horizontal (2:12).

16.7.17.3 Underlayment.
Underlayment shall comply with Clause 16.7.1.1.

16.7.17.5 Fasteners.
Fasteners for photovoltaic shingles shall be galvanized, stainless steel, aluminum or copper roofing nails, minimum 12-gage [2.67 mm (0.105 inch)] shank with a minimum 9.5 mm (3/8 inch) diameter head, of a length to penetrate through the roofing materials and not less than 19.1 mm (3/4 inch) into the roof sheathing. Where the roof sheathing is less than 19.1 mm (3/4 inch) thick, the nails shall penetrate through the sheathing. Fasteners shall comply with ASTM F1667.

16.7.17.6 Material standards.
Photovoltaic shingles shall be listed and labeled in accordance with IEC 61730.

16.7.17.7 Attachment.
Photovoltaic shingles shall be attached in accordance with the manufacturer’s installation instructions.

16.7.17.8 Wind resistance.
Photovoltaic shingles shall be tested in accordance with procedures and acceptance criteria in ASTM D3161. Photovoltaic shingles shall comply with the classification requirements of Table 16.4.1.1 for the appropriate maximum nominal design wind speed. Photovoltaic shingle packaging shall bear a label to indicate compliance with the procedures in ASTM D3161 and the required classification from Table 16.4.1.1.

16.7.18 Building-integrated photovoltaic roof panels.
The installation of building-integrated photovoltaic (BIPV) roof panels shall comply with the provisions of this clause.

16.7.18.1 Deck requirements.
BIPV roof panels shall be applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied over spaced sheathing.

16.7.18.2 Deck slope.
BIPV roof panels shall be used only on roof slopes of two units vertical in 12 units horizontal (2:12) or greater.

16.7.18.3 Underlayment.
Underlayment shall comply with ASTM D226, ASTM D4869 or ASTM D6757.

16.7.18.4 Underlayment application.
Underlayment shall be applied shingle fashion, parallel to and starting from the eave, lapped 51 mm (2 inches) and fastened sufficiently to hold in place.

16.7.18.4.1 High-wind attachment.
Underlayment applied in areas subject to high winds [Vasd greater than 110 mph (49 m/s) as determined in accordance with Clause 1609.3.1] shall be applied in accordance with the manufacturer’s instructions. Fasteners shall be
applied along the overlap at not more than 914 mm (36 inches) on center. Underlayment installed where Vasd is not less than 120 mph (54 m/s) shall comply with ASTM D226, Type II, ASTM D4869, Type III or ASTM D6757. The underlayment shall be attached in a grid pattern of 305 mm (12 inches) between side laps with a 152 mm (6-inch) spacing at the side laps. The underlayment shall be applied in accordance with Clause 16.7.2 except all laps shall be not less than 102 mm (4 inches). Underlayment shall be attached using cap nails or cap staples. Caps shall be metal or plastic with a nominal head diameter of not less than 25.4 mm (1 inch). Metal caps shall have a thickness of not less than 0.25 mm (0.010 inch). Power-driven metal caps shall have a thickness of not less than 0.25 mm (0.010 inch). Thickness of the outside edge of plastic caps shall be not less than 0.89 mm (0.035 inch). The cap nail shank shall be not less than 2.11 mm (0.083 inch) for ring shank cap nails and 2.31 mm (0.091 inch) for smooth shank cap nails. Staple gage shall be not less than 21 gage (0.81 mm (0.0.2 inch)). Cap nail shank and cap staple legs shall have a length sufficient to penetrate through-the-roof sheathing or not less than 19.1 mm (3/4 inch) into the roof sheathing.

Exception: As an alternative, adhered underlayment complying with ASTM D1970 shall be permitted.

16.7.18.5 Material standards. BIPV roof panels shall be listed and labeled in accordance with IEC 61730.

16.7.18.6 Attachment. BIPV roof panels shall be attached in accordance with the manufacturer’s installation instructions.

16.7.18.7 Wind resistance. BIPV roof panels shall be tested in accordance with this Code. BIPV roof panel packaging shall bear a label to indicate compliance with this Code.

16.8 ROOF INSULATION

16.8.1 General. The use of above-deck thermal insulation shall be permitted provided that such insulation is covered with an approved roof covering and passes the tests of the Ghana Fire Code when tested as an assembly.

Exceptions:

1. Foam plastic roof insulation shall conform to the material and installation requirements of Part 27.

2. Where a concrete roof deck is used and the above-deck thermal insulation is covered with an approved roof covering.

16.8.2 Material standards. Above-deck thermal insulation board shall comply with the standards in Table 16.8.2.

**TABLE 16.8.2: MATERIAL STANDARDS FOR ROOF INSULATION**

<table>
<thead>
<tr>
<th>Material</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular glass board</td>
<td>ASTM C552</td>
</tr>
<tr>
<td>Composite boards</td>
<td>ASTM C1289, Type III, IV, V or VII</td>
</tr>
<tr>
<td>Expanded polystyrene</td>
<td>ASTM C578</td>
</tr>
<tr>
<td>Extruded polystyrene</td>
<td>ASTM C578</td>
</tr>
<tr>
<td>Fiber-reinforced gypsum board</td>
<td>ASTM C1278</td>
</tr>
<tr>
<td>Glass-faced gypsum board</td>
<td>ASTM C1177</td>
</tr>
<tr>
<td>High-density polyisocyanurate board</td>
<td>ASTM C1289, Type II, Class 4</td>
</tr>
<tr>
<td>Mineral fiber insulation board</td>
<td>ASTM C726</td>
</tr>
<tr>
<td>Perlite board</td>
<td>ASTM C728</td>
</tr>
<tr>
<td>Polyisocyanurate board</td>
<td>ASTM C1289, Type I or II</td>
</tr>
<tr>
<td>Wood fiberboard</td>
<td>ASTM C208, Type II</td>
</tr>
</tbody>
</table>

16.9 RADIANT BARRIERS INSTALLED ABOVE DECK

16.9.1 General. A radiant barrier installed above a deck shall comply with Clauses 16.9.2 through 16.9.4.

16.9.2 Fire testing. Radiant barriers shall be permitted for use
above decks where the radiant barrier is covered with an approved roof covering and the system consisting of the radiant barrier and the roof covering complies with the requirements.

16.9.3 Installation.
The low emittance surface of the radiant barrier shall face the continuous airspace between the radiant barrier and the roof covering.

16.9.4 Material standards.
A radiant barrier installed above a deck shall comply with ASTM C131³/313M.

16.10 ROOFTOP STRUCTURES

16.10.1 General.
The provisions of this clause shall govern the construction of rooftop structures.

16.10.1.1 Area limitation.
The aggregate area of penthouses and other enclosed rooftop structures shall not exceed one-third the area of the supporting roof deck. Such penthouses and other enclosed rooftop structures shall not be required to be included in determining the building area or number of stories as regulated by Clause 6.3.1. The area of such penthouses shall not be included in determining the fire area specified in Clause 10.1.7.

16.10.2 Penthouses.
Penthouses in compliance with Clauses 16.10.2.1 through 16.10.2.5 shall be considered as a portion of the storey directly below the roof deck on which such penthouses are located. Other penthouses shall be considered as an additional storey of the building.

16.10.2.1 Height above roof deck.
Penthouses constructed on buildings of other than Type I construction shall not exceed 5486 mm (18 feet) in height above the roof deck as measured to the average height of the roof of the penthouse. Penthouses located on the roof of buildings of Type I construction shall not be limited in height.

Exception: Where used to enclose tanks or elevators that travel to the roof level, penthouses shall be permitted to have a maximum height of 8534 mm (28 feet) above the roof deck.

16.10.2.2 Use limitations.
Penthouses shall not be used for purposes other than the shelter of mechanical or electrical equipment, tanks, elevators and related machinery, or vertical shaft openings in the roof assembly.

16.10.2.3 Weather protection.
Provisions such as louvers, louver blades or flashing shall be made to protect the mechanical and electrical equipment and the building interior from the elements.

16.10.2.4 Type of construction.
Penthouses shall be constructed with walls, floors and roofs as required for the type of construction of the building on which such penthouses are built.

Exceptions:

1. On buildings of Type I construction, the exterior walls and roofs of penthouses with a fire separation distance greater than 5 feet (1524 mm) and less than 20 feet (6096 mm) shall be permitted to have not less than a 1-hour fire-resistance rating. The exterior walls and roofs of penthouses with a fire separation distance of 20 feet (6096 mm) or greater shall not be required to have a fire-resistance rating.

2. On buildings of Type I construction two stories or less in height above grade plane or of Type II construction, the exterior walls and roofs of penthouses with a fire separation distance greater than 5 feet (1524 mm) and less than 20 feet (6096 mm) shall be permitted to have not less than a 1-hour fire-resistance rating or a lesser fire-resistance rating as required by Table 602 and be constructed of fire-retardant-treated wood. The exterior walls and roofs of penthouses with a fire separation distance of 20 feet (6096 mm) or greater shall be permitted to be constructed of fire-retardant-treated wood and shall not be required to have a
fire-resistance rating. Interior framing and walls shall be permitted to be constructed of fire-retardant-treated wood.

3. On buildings of Type II, III or IV construction, the exterior walls of penthouses with a fire separation distance greater than 5 feet (1524 mm) and less than 20 feet (6096 mm) shall be permitted to have not less than a 1-hour fire-resistance rating or a lesser fire-resistance rating as required by Table 7.2. On buildings of Type II, III or IV construction, the exterior walls of penthouses with a fire separation distance of 20 feet (6096 mm) or greater shall be permitted to be of heavy timber construction complying with Clauses 7.2.4 and 24.4.11 or noncombustible construction or fire-retardant-treated wood and shall not be required to have a fire-resistance rating.

16.10.3 Tanks.

Tanks having a capacity of more than 500 gallons (1893 L) located on the roof deck of a building shall be supported on masonry, reinforced concrete, steel or heavy timber construction complying with Clause 24.4.11 provided that, where such supports are located in the building above the lowest storey, the support shall be fire-resistance rated as required for Type IA construction.

16.10.3.1 Valve and drain.

In the bottom or on the side near the bottom of the tank, a pipe or outlet, fitted with a suitable quick-opening valve for discharging the contents into a drain in an emergency shall be provided.

16.10.3.2 Location.

Tanks shall not be placed over or near a stairway or an elevator shaft, unless there is a solid roof or floor underneath the tank.

16.10.3.3 Tank cover.

Unenclosed roof tanks shall have covers sloping toward the perimeter of the tanks.

16.10.4 Cooling towers.

Cooling towers located on the roof deck of a building and greater than 250 square feet (23.2 $m^2$) in base area or greater than 4572 mm (15 feet) in height above the roof deck, as measured to the highest point on the cooling tower, where the roof is greater than 50 feet (15 240 mm) in height above grade plane shall be constructed of noncombustible materials. The base area of cooling towers shall not exceed one-third the area of the supporting roof deck.

Exception: Drip boards and the enclosing construction shall be permitted to be of wood not less than 25 mm (1 inch) nominal thickness, provided that the wood is covered on the exterior of the tower with noncombustible material.

16.10.5 Towers, spires, domes and cupolas.

Towers, spires, domes and cupolas shall be of a type of construction having fire-resistance ratings not less than required for the building on top of which such tower, spire, dome or cupola is built. Towers, spires, domes and cupolas greater than 25 908 mm (85 feet) in height above grade plane as measured to the highest point on such structures, and either greater than 18.6 $m^2$ (200 square feet) in horizontal area or used for any purpose other than a belfry or an architectural embellishment, shall be constructed of and supported on Type I or II construction.

16.10.5.1 Noncombustible construction required.

Towers, spires, domes and cupolas greater than 18 288 mm (60 feet) in height above the highest point at which such structure contacts the roof as measured to the highest point on such structure, or that exceeds 18.6 $m^2$ (200 square feet) in area at any horizontal clause, or which is
intended to be used for any purpose other than a belfry or architectural embellishment, or is located on the top of a building greater than 1524 mm (50 feet) in building height shall be constructed of and supported by noncombustible materials and shall be separated from the building below by construction having a fire-resistance rating of not less than 1.5 hours with openings protected in accordance with Clause 711. Such structures located on the top of a building greater than 15240 mm (50 feet) in building height shall be supported by noncombustible construction.

16.10.5.2 Towers and spires.

Enclosed towers and spires shall have exterior walls constructed as required for the building on top of which such towers and spires are built. The roof covering of spires shall be not less than the same class of roof covering required for the building on top of which the spire is located.

16.10.6 Mechanical equipment screens.

Mechanical equipment screens shall be constructed of the materials specified for the exterior walls in accordance with the type of construction of the building. Where the fire separation distance is greater than 1524 mm (5 feet), mechanical equipment screens shall not be required to comply with the fire-resistance rating requirements.

16.10.6.1 Height limitations.

Mechanical equipment screens shall not exceed 5486 mm (18 feet) in height above the roof deck, as measured to the highest point on the mechanical equipment screen.

Exception: Where located on buildings of Type IA construction, the height of mechanical equipment screens shall not be limited.

16.10.6.2 Type I, II or III construction.

Regardless of the requirements in Clause 16.10.6, mechanical equipment screens that are located on the roof decks of buildings of Type I, II or III construction shall be permitted to be constructed of combustible materials in accordance with any one of the following limitations:

1. The fire separation distance shall be not less than 6096 mm (20 feet) and the height of the mechanical equipment screen above the roof deck shall not exceed 1219 mm (4 feet) as measured to the highest point on the mechanical equipment screen.

2. The fire separation distance shall be not less than 6096 mm (20 feet) and the mechanical equipment screen shall be constructed of fire-retardant-treated wood complying with Clause 24.3.2 for exterior installation.

3. Where exterior wall covering panels are used, the panels shall have a flame spread index of 25 or less when tested in the minimum and maximum thicknesses intended for use, with each face tested independently in accordance with ASTM E84. The panels shall be tested in the minimum and maximum thicknesses intended for use in accordance with, and shall comply with the acceptance criteria of, the Ghana Fire Code and shall be installed as tested. Where the panels are tested as part of an exterior wall assembly in accordance with the Ghana Fire Code, the panels shall be installed on the face of the mechanical equipment screen supporting structure in the same manner as they were installed on the tested exterior wall assembly.

16.10.6.3 Type IV construction.

The height of mechanical equipment screens located on the roof decks of buildings of Type IV construction, as measured from grade plane to the highest point on the mechanical equipment screen, shall be permitted to exceed the maximum building height allowed for the building by other provisions of this Code where complying with any one of the following limitations, provided that the fire separation distance is greater than 1524 mm (5 feet):
1. Where the fire separation distance is not less than 6096 mm (20 feet), the height above grade plane of the mechanical equipment screen shall not exceed 1219 mm (4 feet) more than the maximum building height allowed.

2. The mechanical equipment screen shall be constructed of noncombustible materials.

3. The mechanical equipment screen shall be constructed of fire-retardant-treated wood complying with Clause 24.3.2 for exterior installation.

4. Where the fire separation distance is not less than 6096 mm (20 feet), the mechanical equipment screen shall be constructed of materials having a flame spread index of 25 or less when tested in the minimum and maximum thicknesses intended for use with each face tested independently in accordance with ASTM E84.

16.10.7 Photovoltaic panels and modules.
Rooftop-mounted photovoltaic panels and modules shall be designed in accordance with this clause.

16.10.7.1 Fire classification.
Rooftop-mounted photovoltaic panels and modules shall have the fire classification in accordance with the Ghana Fire Code.

16.10.7.2 Photovoltaic panels and modules.
Rooftop-mounted photovoltaic panels and modules shall be listed and labeled in accordance with IEC 61730 and shall be installed in accordance with the manufacturer’s instructions.

16.10.8 Other rooftop structures.
Rooftop structures not regulated by Clauses 16.10.2 through 16.10.7 shall comply with Clauses 16.10.8.1 through 16.10.8.5, as applicable.

16.10.8.1 Aerial supports.
Aerial supports shall be constructed of noncombustible materials.

Exception: Aerial supports not greater than 3658 mm (12 feet) in height as measured from the roof deck to the highest point on the aerial supports shall be permitted to be constructed of combustible materials.

16.10.8.2 Bulkheads.
Bulkheads used for the shelter of mechanical or electrical equipment or vertical shaft openings in the roof assembly shall comply with Clause 16.10.2 as penthouses. Bulkheads used for any other purpose shall be considered as an additional storey of the building.

1610.8.3 Dormers.
Dormers shall be of the same type of construction as required for the roof in which such dormers are located or the exterior walls of the building.

16.10.8.4 Fences.
Fences and similar structures shall comply with this Code as mechanical equipment screens.

16.10.8.5 Flagpoles.
Flagpoles and similar structures shall not be required to be constructed of noncombustible materials and shall not be limited in height or number.

16.10.9 Structural fire resistance.
The structural frame and roof construction supporting loads imposed upon the roof by any rooftop structure shall comply with the requirements of this Code. The fire-resistance reduction permitted by this Code, Note a, shall not apply to roofs containing rooftop structures.

16.11 REROOFING

16.11.1 General.
Materials and methods of application used for recovering or replacing an existing roof covering shall comply with the requirements of Part 16.

Exceptions:

1. Roof replacement or roof recover of existing low-slope roof coverings shall not be required to meet the
minimum design slope requirement of one-quarter unit vertical in 12 units horizontal (2-percent slope) in this Code for roofs that provide positive roof drainage.

2. Recovering or replacing an existing roof covering shall not be required to meet the requirement for secondary (emergency overflow) drains or scuppers in this Code for roofs that provide for positive roof drainage. For the purposes of this exception, existing secondary drainage or scupper systems required in accordance with this Code shall not be removed unless they are replaced by secondary drains or scuppers designed and installed in accordance with this Code.

16.11.2 Structural and construction loads.
Structural roof components shall be capable of supporting the roof-covering system, ceiling systems, materials and equipment loads that will be encountered during installation of the system.

16.11.3 Roof replacement.
Roof replacement shall include the removal of all existing layers of roof coverings down to the roof deck.

Exception: Where the existing roof assembly includes an ice barrier membrane that is adhered to the roof deck, the existing ice barrier membrane shall be permitted to remain in place and covered with an additional layer of ice barrier membrane in accordance with Clause 16.7.

16.11.3.1 Roof recover.
The installation of a new roof covering over an existing roof covering shall be permitted where any of the following conditions occur:

1. Where the new roof covering is installed in accordance with the roof covering manufacturer's approved instructions.

2. Complete and separate roofing systems, such as standing-seam metal roof panel systems, that are designed to transmit the roof loads directly to the building's structural system and that do not rely on existing roofs and roof coverings for support, shall not require the removal of existing roof coverings.

3. Metal panel, metal shingle and concrete and clay tile roof coverings shall be permitted to be installed over existing wood shake roofs when applied in accordance with Clause 16.11.

4. The application of a new protective roof coating over an existing protective roof coating, metal roof panel, built-up roof, spray polyurethane foam roofing system, metal roof shingles, mineral-surfaced roll roofing, modified bitumen roofing or thermoset and thermoplastic single-ply roofing shall be permitted without tear off of existing roof coverings.

16.11.3.1.1 Exceptions.
A roof recover shall not be permitted where any of the following conditions occur:

1. Where the existing roof or roof covering is water soaked or has deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.

2. Where the existing roof covering is slate, clay, cement or asbestos-cement tile.

3. Where the existing roof has two or more applications of any type of roof covering.

16.11.4 Roof recovering.
Where the application of a new roof covering over wood shingle or shake roofs creates a combustible concealed space, the entire existing surface shall be covered with gypsum board, mineral fiber, glass fiber or other approved materials securely fastened in place.
16.11.5 Reinstallation of materials.

Existing slate, clay or cement tile shall be permitted for reinstallation, except that damaged, cracked or broken slate or tile shall not be reinstalled. Existing vent flashing, metal edgings, drain outlets, collars and metal counterflashings shall not be reinstalled where rusted, damaged or deteriorated. Aggregate surfacing materials shall not be reinstalled.

16.11.6 Flashings.

Flashings shall be reconstructed in accordance with approved manufacturer’s installation instructions. Metal flashing to which bituminous materials are to be adhered shall be primed prior to installation.

16.12 PHOTOVOLTAIC PANELS AND MODULES

16.12.1 Photovoltaic panels and modules.
Photovoltaic panels and modules installed on a roof or as an integral part of a roof assembly shall comply with the requirements of this Code and the Ghana Fire Code.
PART 17: STRUCTURAL LOADS AND DESIGN

User notes:

About this part: Part 17 establishes minimum design requirements so that the structural components of buildings are proportioned to resist the loads that are likely to be encountered. In addition, this part assigns buildings and structures to risk categories that are indicative of their intended use. The loads specified herein along with the required load combinations have been established through research and service performance of buildings and structures. The application of these loads and adherence to the serviceability criteria enhances the protection of life and property.

17.1 SCOPE

17.1.1 This clause covers all dead loads and imposed loads which shall be sustained and transmitted by a building and certain structures without exceeding the stress limitations specified elsewhere in the Code. It applies to:

(1) new buildings and new structures;
(2) alterations and additions to existing buildings and structures;
(3) existing constructions on change of use.

17.1.2 This part of the Code does not cover

(1) loads on roads and rail bridges;
(2) loads on structures subject to internal pressure from contents, (e.g. bunkers, silos and water tanks) which should be calculated individually;
(3) loads due to machinery vibration, except those due to some gantry cranes;
(4) loads due to lifts;
(5) loads incidental to construction;
(6) test loads.

These loads are covered by specialized (proprietary) documents produced by manufacturers.

17.2 DESIGN REQUIREMENTS

17.2.1 (1) Buildings and their structural members including formwork and falsework shall be designed to have sufficient structural capacity to resist safely and effectively all loads and effects of loads and influences that may reasonably be expected, having regard to the expected service life of buildings.

(2) All permanent and temporary structural members, including formwork and falsework of a building, shall be protected against loads exceeding the design loads during the construction period except when, as verified by analysis or test, temporary overloading of a structural member would result in no impairment of that member or any other member. In addition, precautions shall be taken during all stages of construction to ensure that the building is not damaged or distorted due to loads applied during construction.

17.2.2 Design Basis

Buildings and their structural members shall be designed by one of the following methods:

(1) analysis based on well-established principles of mechanics;
(2) evaluation of a given full-scale structure or a prototype by a loading test;
(3) Studies of model analogues (modeling).

17.2.3 Deflections

(1) Structural members shall be designed so that their deflections under expected service loads will be acceptable with regard to:

(a) the intended use of building or member;
(b) possible damage to non-structural members and materials;
(c) Possible damage to the structure itself and, where significant, the additional effects of loads acting on the deformed structure.
(2) Deflections listed in clause 17.2.3(1) shall be taken into account in all structures and structural members made of material susceptible to deflections, deformations or changes in load distribution due to creep, shrinkage or other effects in the materials of which they are composed.

(3) The lateral deflection of buildings due to design wind and gravity loads shall be checked to ensure that non-structural elements, whose nature is known at the time the structural design is carried out, will not be damaged. Except as provided in Clause 17.2.3(4) and unless otherwise approved, the total drift per storey under design wind and gravity loads shall not exceed 1/500 of the storey height.

(4) The deflection limits required in Clause 17.2.3(3) does not apply to industrial buildings or sheds if it is known by experience that greater movement is acceptable.

17.2.4 Vibrations of Floors

(1) Special considerations shall be given to floor systems susceptible to vibration to ensure that such vibration is acceptable for the intended occupancy of the building.

(2) Lateral Deflections of Tall Buildings:
Unusually flexible buildings and buildings whose ratio of height to minimum effective width exceeds 4 to 1 shall be investigated for lateral vibrations under dynamic wind loading. Lateral accelerations of the building shall be checked to ensure that such accelerations are acceptable to the intended occupancy of the building.

(3) Stability under Compressive stress:
Provision shall be made to ensure adequate stability of a structure as a whole, and adequate lateral, torsional and local stability of all structural parts which may be subject to compressive stress.

17.3 CONSTRUCTION DOCUMENTS

17.3.1 General.
Construction documents shall show the size, clause and relative locations of structural members with floor levels, column centres and offsets dimensioned. The design loads and other information pertinent to the structural design required by Clauses 17.3.1.1 through 17.3.1.9 shall be indicated on the construction documents.

Exception: Construction documents for buildings constructed in accordance with the conventional light-frame construction provisions of Clause 24.8 shall indicate the following structural design information:

1. Floor and roof dead and live loads.
2. Ground snow load, \( P_g \).
3. Basic design wind speed, \( V \), miles per hour (mph) (km/hr) and allowable stress design wind speed, \( V_{asd} \), as determined in accordance with Clause 1609.3.1 and wind exposure.
4. Seismic design category and site class.
5. Flood design data, if located in flood hazard areas established in Clause 1612.3.
6. Design load-bearing values of soils.
7. Rain load data.

17.3.1.1 Floor live load.
The uniformly distributed, concentrated and impact floor live load used in the design shall be indicated for floor areas. Use of live load reduction in accordance with this Code shall be indicated for each type of live load used in the design.
17.3.1.2 Roof live load.

The roof live load used in the design shall be indicated for roof areas this Code.

(1) Structural drawings submitted with the application to build shall bear the signature of the designer.

(2) Drawings submitted with the application to build shall indicate in addition to those items specified elsewhere in other clauses of Part 5, applicable to a specific material:

(a) the name and address of persons responsible for the structural design;

(b) the Code or standard to which the design conforms;

(c) the dimensions, location and size of all structural members in sufficient detail to enable the design to be checked;

(d) sufficient detail to enable the loads due to materials of construction incorporated in the building to be determined;

(e) all intended uses and occupancies;

(f) all effects and loads, other than dead loads used in the design of structural members.

(3) The calculations and analysis made in the design of the structural members, including parts and components of a building shall be available upon request for inspection by the authority having jurisdiction.

(4) Structural integrity: Buildings and structural systems shall provide such structural integrity, strength or other defenses that the hazards associated with progressive collapse due to local failure caused by severe overloads or abnormal events not specifically covered in this clause are reduced to a level commensurate with good engineering practice.

17.3.6 Inspection of Construction

(1) Inspection of the construction of any building or part thereof shall be carried out by the designer, or by another suitably qualified person responsible to the designer, to ensure that the construction conforms with the design.

(2) The designer or another suitably qualified person familiar with the design concept and responsible to the designer, shall review all shop drawings and other drawings relevant to the design to ensure conformance to the design.

(3) Workmanship and Materials: Workmanship and materials shall be inspected and all reports of material tests shall be reviewed by the designer or another suitably qualified person responsible to the designer during the process of construction.

(4) Off-site inspections: Where a building or a component of a building is assembled off the building site, in a manner that it cannot be inspected on site, approved off-site inspection shall be provided when required by the authority having jurisdiction to ensure compliance with this Code.

(5) Inspection Reports: Copies of all inspection reports shall be made available by the designer upon request to the authority having jurisdiction.

17.4 DESIGN LOADS AND EFFECTS

17.4.1 (1) Except as provided for in Clause 17.4.2, the following characteristic loads, forces and effects shall be considered in the design of a building and its structural members and connections:

\( G_k \) – Dead load: Is the self-weight of the structure and the weight of finishes, ceilings, services and partitions (see BS 6399: Part 1, Loadings for buildings. Code of practice for dead and imposed loads) and Appendix A.

\( Q_k \)– Live (or Imposed or Variable) load: Due to intended use and occupancy (include loads due to movable partitions and vertical loads due to cranes) and rain

\( W_k \)– Wind load: Depends on the location, shape and dimension of the buildings. Loadings for buildings: Code of practice for wind loads) and Clause 17.9 of this Part.
**Eₙ - Nominal earth loads:** Earth and hydrostatic pressure, surcharge, horizontal components of static or inertia forces (see BS 8004: Code of practice for Foundations).

**E** – Earthquake load (See Clause 17.10 of this Part)

**T** – Contraction or expansion due to temperature changes, shrinkage, moisture changes, creep in component materials, movement due to differential settlement or combination thereof

17.4.2 (1) Where a building or structural member can be expected to be subjected to loads, forces or other effects not listed in Clause 17.4.1; such effects shall be taken into account in the design based on the most appropriate information available.

(2) If it can be shown by engineering principles or if it is known from experience, that neglect of some or all the effects due to T do not affect the structural safety and serviceability, they need not be considered in the calculations.

17.4.3 Structural design shall be carried out in accordance with Clause 17.5 ‘Limit State Design’.

### 17.5 LIMIT STATE DESIGN

17.5.1 (1) In this clause the term **Limit State** means those conditions of a building structure in which the building ceases to fulfill the function or to satisfy the conditions for which it was designed.

Limit State Design admits that a structure can become unsatisfactory in various ways, all of which need to be considered against defined limits of acceptability.

By providing sufficient margins of safety against inherent variability in loading (actions), material properties, environmental conditions, design methods and construction practices, limit state design aims at giving an acceptable probability that the structure will perform satisfactorily during its intended working life.

The limit states can be placed in two categories:

(a) **Ultimate limit states**, which are those corresponding to maximum load-carrying capacity and safety of people and the structure e.g.

(i) Loss of equilibrium (overturning) of part or the whole of the structure when considered as a rigid body.

(ii) Rupture of critical clauses of the structure.

(iii) Transformation of structure into a mechanism.

(iv) Failure through excessive deformation.

(v) Deterioration arising out of fatigue effects.

(b) **Serviceability limit states**, which are related to the criteria governing normal use or durability e.g.

(i) Excessive deformations with respect to normal use of structure.

(ii) Premature or excessive cracking.

(iii) Undesirable damage (corrosion).

(iv) Excessive displacement without loss of equilibrium.

(v) Excessive vibrations.

(vi) The comfort of people.

(vii) The appearance of the structure.

(2) Characteristic loads ($G_K, Q_K, W_K, E_n, E, T$) means those loads defined in Clause 17.4.1.

(3) Partial safety factors to the value of loads ($\gamma$), used in design in clause 17.5.2 that takes account of the possibility of unfavourable deviations of the action values, uncertainties in modeling the effects of actions, and the significance of the particular limit state.
(4) Partial safety factors to the values of material properties ($\gamma_m$) used in design. This makes allowances for sub-standard materials or for the deterioration of materials during the life of the structure.

(5) Action combination factor, $\psi$, which for imposed (variable) loads, are used in multiplying characteristic values to obtain representative values. The use of factors $\psi$ reduce the design values of more than one variable load when they act together see Table 17.3.

(6) For imposed (variable) loads, under EuroCode (see 17.3):

representative values = characteristic value x $\psi$

(7) In most cases, the design value of an action (load combination) can be expressed as:

design value = representative value x $\gamma_f$

17.5.2 Methods of Limit State Design

17.5.2.1 Ghana, British System GS (BS 8110: Part 1)

17.5.2.1.1 Required Strength for Ultimate Limit State

(1) The required strength $R$ provided to resist dead load $G_K$ and imposed load $Q_K$ shall be at least equal to:

$$ R = 1.4G_K + 1.6Q_K \quad \text{……… (17-1)} $$

(2) In the design of a structure or member, if resistance to the structural effects of a specified wind load $W_K$, must be included in the design the following combinations of $G_K$, $Q_K$ and $W_K$ shall be investigated in determining the greatest required strength $R$.

$$ R = 1.2G_K + 1.2Q_K + 1.2W_K \quad \text{……… (17-2)} $$

Where the cases of $Q_K$ having its full value or being completely absent shall both be checked to determine the most severe condition using

$$ R = 0.9G_K + 1.4W_K \quad \text{……… (17-3)} $$

In any case, the strength of the member or structure shall not be less than required by Eq. (17-1).

(3) If resistance to specified earthquake loads or forces $E$ must be included in the design, refer to Clause 17.10 of this Part on Effects of Earthquake.

(4) If lateral earth pressure $H$ must be included in design the strength $R$ shall be at least equal to $1.4G_K + 1.6Q_K + 1.6H$ but where $G_K$ or $Q_K$ reduce the effect of $H$ (i.e. favourable), the corresponding coefficients shall be taken as 0.90 for $G_K$ and zero for $Q_K$ i.e. the governing equations are:

$$ R = 1.4G_K + 1.6Q_K + 1.6H $$

(5) For lateral loads $F$ due to liquids, the provisions for Clause 17.5.2.1(4) shall apply, except that $1.4F$ shall be substituted for $1.6H$. The vertical pressure of liquids shall be considered as dead load, with due regard to variation in liquid depth.

(6) Where the structural effects of differential settlement, creep, shrinkage or temperature $T$ may be significant the governing equation shall be

$$ R = 1.2G_K + 1.2Q_K + 1.2T $$

The above actions are summarized in Table 17.1
Table 17.1 – Load combinations for Ultimate Limit State

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>Load Type</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dead Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adverse</td>
<td>1.4</td>
<td>1.6</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Beneficial</td>
<td>1.0</td>
<td>0</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Imposed Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adverse</td>
<td>1.4</td>
<td>-</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Beneficial</td>
<td>1.0</td>
<td>-</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Earth and Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pressure</td>
<td>1.4</td>
<td>1.4</td>
<td>1.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

17.5.2.1.2 Values for a Serviceability Limit State

A building and its structural components shall be checked for serviceability limit states as defined in Clause 17.5.1(b). Where more than one load contributes to the stress in the member the combination of loads shall be assumed to be:

\[ G_K + \psi ((Q_K + (E or W_K) + T)) \]

Where \( \psi \) shall be equal to:

(a) 1.0 when only one of the loads \( Q_K \), \( E \) or \( W_K \) and \( T \) act;

(b) 0.70 when two of the loads \( Q_K \), \( E \) or \( W_K \) and \( T \) act;

(c) 0.60 when all of the loads \( Q_K \), \( E \) or \( W_K \) and \( T \) act.

17.5.2.2 EuroCode System GS (BS EN 1990, BS EN 1991, BS EN 1992)

One of the main differences between the EuroCodes and the British/Ghanaian system is the use of different partial safety factors and the option to refine/reduce load factors when different load cases are combined.

17.5.2.2.1 Required strength for Ultimate Limit State

The design loads are obtained by multiplying the characteristic loads by the appropriate partial safety factor, \( \gamma_f \), from Table 17.2.

When more than one imposed load (variable action) is present, the secondary imposed load may be reduced by the application of a combination factor, \( \psi_0 \) (see Table 17.4).

The basic load combination for the required strength at ultimate limit state for a typical building is:

\[ R = \gamma_G G_K + \gamma_Q Q_K + \sum \gamma_0 \psi_0 Q_i \]

where:

\( Q_{k1}, Q_{k2}, Q_{k3} \) etc. are the actions due to vertical imposed loads, wind load, snow etc., \( Q_{k1} \) being the leading action for the situation considered.

The ‘unfavourable’ and ‘favourable’ factors should be used so as to produce the most onerous condition. Generally, permanent actions from a single load source may be multiplied by either the ‘unfavourable’ or the ‘favourable’ factor.
Table 17.2 – Action Combinations for Ultimate Limit States (BS EN 1990: Table NA.A1.2 (B))

<table>
<thead>
<tr>
<th>Option</th>
<th>Permanent Actions (Dead Loads)</th>
<th>Variable Actions (Imposed, Wind Loads)</th>
<th>Earth and Water*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unfavourable</td>
<td>Favourable</td>
<td>Leading</td>
</tr>
<tr>
<td>1</td>
<td>1.35G_K</td>
<td>1.0G_K</td>
<td>1.5Q_K,1</td>
</tr>
<tr>
<td>2a</td>
<td>1.35G_K</td>
<td>1.0G_K</td>
<td>1.5ψ_Q_K,1</td>
</tr>
<tr>
<td>2b</td>
<td>1.25G_K</td>
<td>1.0G_K</td>
<td>1.5Q_K,1</td>
</tr>
</tbody>
</table>

Note: If the water pressure calculated is the most unfavourable value that could occur during the life of the structure, a partial factor of 1.0 may be used.

Based on Table 17.2, a summary of EuroCode Partial Load Factors is given in Table 17.3 for the ultimate limit state.

Table 17.3 – Partial safety factors for loads at the ultimate limit state

<table>
<thead>
<tr>
<th>Limit State</th>
<th>Permanent Actions (G_K)</th>
<th>Variable Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unfavourable</td>
<td>Favourable</td>
</tr>
<tr>
<td>(a)Static equilibrium</td>
<td>1.10</td>
<td>0.90</td>
</tr>
<tr>
<td>(b)Structural strength</td>
<td>1.35</td>
<td>1.00</td>
</tr>
<tr>
<td>(c)As an alternative to (a) and (b) above to design for both situations</td>
<td>1.35</td>
<td>1.15</td>
</tr>
</tbody>
</table>
with one set of calculation

(d) Geotechnical strength 1.35 0.00 1.35 0.00 1.35 0.00

Note: For general guidance only.

17.5.2.2.2 Values for Serviceability Limit State

The action (load) combination for checking the requirement at the serviceability limit state is generally of the form:

$$ G_K + Q_{K,1} + \sum \psi_0 Q_{K,i} $$

Where, $G_K$, $Q_{K,1}$ and $Q_{K,i}$ are permanent action (dead load), leading variable action (imposed load) and other secondary variable actions (where more than one imposed load contributes to the stresses) respectively. In the case of the secondary variable load(s), their effect(s) may be reduced by the application of the combination factors as given in Table 17.4. The corresponding load cases for the serviceability limit states are given in Table 17.5.

Table 17.4 – Combination reduction factors, $\psi$, for buildings

<table>
<thead>
<tr>
<th>Action</th>
<th>$\psi_0$</th>
<th>$\psi_1$</th>
<th>$\psi_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic, residential area</td>
<td>0.7</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Office area</td>
<td>0.7</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Congregation areas</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Shopping areas</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Storage areas</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Traffic area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle $\leq 30kN$</td>
<td>0.7</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Traffic area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$30kN \leq$ Vehicle $\leq 160kN$</td>
<td>0.7</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Roofs</td>
<td>0.7</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Wind loads</td>
<td>0.5</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Temperature (non-fire)</td>
<td>0.6</td>
<td>0.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 17.5 – Serviceability Load cases

<table>
<thead>
<tr>
<th>Design requirement</th>
<th>Action Combinations</th>
<th>Permanent (Dead load) Actions</th>
<th>Variable (Imposed load) Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function and damage to elements, including partitions and finishes</td>
<td>Characteristic</td>
<td>$G_K$</td>
<td>Leading $Q_{K,1}$</td>
</tr>
<tr>
<td>User comfort, use of machinery, avoiding</td>
<td>Frequent</td>
<td>1.0</td>
<td>$\psi_0$</td>
</tr>
</tbody>
</table>
ponding of water

| Appearance of the structure or element | Quasi-permanent | $\Psi_2$ | $\Psi_2$ |

17.6 DEAD LOADS

17.6.1 (1) Dead loads shall be calculated from unit weight given in Appendix A to this part or from materials not provided for in that Appendix as specified or agreed upon with the Authority having jurisdiction.

(2) When partitions are shown in plans, their actual weights shall be included in the dead load. For all floors in which partition walls are or may be intended but are not located on the plans, the beams and the floor slabs where these are capable of effective lateral distribution of the load, shall be designed to carry in addition to other loads, a uniformly distributed load per square metre of not less than one third of the weight per metre run of the finished partitions, but not less than 1kN/m² if the floor is used for office purposes.

17.7 LIVE (IMPOSED) LOADS DUE TO USE AND OCCUPANCY

17.7.1 The minimum live load to be provided for shall be as set out in the Clauses of this Part, or, where not covered by these Clauses, as specified or agreed upon with the Administering Authority. In all cases the live load or loads shall be so placed that in combination with dead load the maximum stresses are produced in the member or members being designed.

17.7.2 Floor Live Loads

(1) The minimum floor live loads to be provided for shall be taken as being equal to an equivalent uniform static Load or concentrated load whichever produces greater stresses and shall be based on the intended use and occupancy as set out in Table 17.6 of this Clause. The concentrated loads applied over a specified area of a square with a 300mm side shall be located so as to cause maximum effects.

Table 17.6 provides for normal effects of ordinary impact and acceleration but does not include any allowance for special concentrated loads. Special provision shall be made for moving loads other than those in garages for machinery and other concentrated loads as set out in Clause 17.8.

(2) The concentrated imposed load need not be considered where the floor slab is capable of effective lateral distribution of this load.

(3) All beams shall be designed to carry the distribution load appropriate to the uses to which they are to be put as given in Table 17.6.

(4) Beams, ribs and joists spaced at not more than 1 metre centres may be designed as floor slabs.

(5) Where in Table 17.6 no values are given for concentrated load, it may be assumed that the tabulated distributed load is adequate for design purposes.
(6) Where an area of floor is intended for 2 or more occupancies at different times, the
value to be used from Table 17.6 shall be the greatest value for any of the occupancies
concerned.

(7) When the occupancy of a building is changed the building shall conform to the
requirements of this part of the Code for the new occupancy.

17.7.3 Reduction in Total Imposed Floor Loads

(1) Except as provided for in 17.7.3(2) and 17.7.3(3), the reduction in assumed total imposed
floor loads defined below may be taken in designing columns, piers, walls, their support and
foundations. For purposes of 5.7.2(1) to 5.7.3(3), a roof may be regarded as a floor.

Let, \( L_o \) be the imposed load upon the roof and let \( L_1, L_2, L_3 \ldots L_n \) be the respective imposed
loads upon the floors numbered 1, 2, 3 \ldots n starting from the top of the building.

For the design of the points of support the following imposed loads may be adopted:

Supports under roof \( L_o \)

Supports under top floor (floor 1) \( L_o + L_1 \)

Supports under floor 2 \( L_o + 0.95(L_1+L_2) \)

Supports under floor 3 \( L_o + 0.9(L_1+L_2 + L_3) \)

Supports under floor 4 \( L_o + 0.85(L_1+L_2 + L_3 + L_4) \)

Supports under floor n \( L_o + \frac{3+n}{2n} (L_1+L_2 + L_3 \ldots L_n) \)

The coefficient \((3+n)/2n\) is valid for \( n > 5 \)

For factories and workshops designed for 5kN/m\(^2\) or more, the reductions shown above may be
taken provided the loading assumed is not less than it would have been if all floors had been
designed for 5kN/m\(^2\) with no reductions.

(2) Where a single span of a beam or girder supports not less than 46m\(^2\) of floor at one general
level, the imposed load may, in the design of beam or girder, be reduced by 5\% for each 46m\(^2\)
supported, subject to a maximum reduction of 25\%. This reduction or that given in 5.7.3(1),
whichever is greater, may be taken into account in the design of columns or other type member
supporting such a beam.

(3) No reduction shall be made for any plant or machinery which is specifically allowed for or for
buildings for storage purposes, warehouses, garages and those office areas which are used for
storage and filing purposes.

17.7.4 Roof Live Loads other than Wind Loads or Rain Loads.

(1) Flat Roofs

545
Flat roofs to which there is no direct access (except only such cases as is necessary for cleaning and repairs) shall withstand an imposed load of 0.25kN/m$^2$ measured on plan or a load of 0.9kN concentrated on a square with 300mm side whichever produces the greater stress.

(2) On flat floors where access (in addition to that necessary for cleaning and repair) is provided to the roof, allowance shall be made for an imposed load of 1.5kN/m$^2$ measured on plan or a load of 1.8kN concentrated on a square with a 300mm side.

### Table 17.6 - Uses and Loads

<table>
<thead>
<tr>
<th>Occupancy or Use</th>
<th>Intensity of Distributed Loads (kN/m$^2$)</th>
<th>Concentrated Load to be applied unless otherwise stated over any square with a 300-mm side (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multifamily house</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Private apartments</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Public rooms</td>
<td>5.0</td>
<td>-</td>
</tr>
<tr>
<td>Corridors</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Dwellings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not exceeding 2 storeys</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Exceeding 2 storeys</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Hotels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guest rooms</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>Public rooms</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Corridors serving public rooms</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Corridors above first floor</td>
<td>4.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>
### 4. Office buildings

<table>
<thead>
<tr>
<th>Areas (not including computer rooms) located in basement and first floor</th>
<th>5.0</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>File, rooms in offices</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Floors above first floor</td>
<td>2.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Area with computing data processing and similar equipment</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Toilet rooms</td>
<td>2.0</td>
<td>-</td>
</tr>
</tbody>
</table>

### 5. Assembly areas with fixed seats

*including:*

- Auditoria
- Churches
- Courtrooms
- Lecture halls
  - Theatres and other areas with similar uses

|  | 4.0 | - |

### 6. Assembly areas without fixed seats

*including:*

- Arenas
- Arenas
- Balconies
- Dance floors
- Dining areas
- Foyers and entrance hall
- Grandstands
- Reviewing stands
- Gymnasia
- Museums

<p>| | | | | | | | | | | | |
|  | - | - | - | - | - | - | - | - | - | - | - |</p>
<table>
<thead>
<tr>
<th>Area</th>
<th>Height</th>
<th>Per Square Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stadia</strong></td>
<td>5.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Stages and other areas with similar uses</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Drill rooms and Drill halls</strong></td>
<td>5.0</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>Garage for passenger cars unloaded buses</strong></td>
<td>2.5</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>and light trucks not exceeding 2500kg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>including driveways and ramps</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All repair workshops for all types of vehicle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>and parking for vehicles exceeding 2500kg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>gross weight including driveways and ramps</strong></td>
<td>2.5</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>Libraries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading and study rooms without book storage</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Rooms with book storage (eg. Public lending libraries)</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Stack Rooms</strong></td>
<td>2.4</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Schools and Colleges</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classrooms</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Dormitories</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Gymnasia</td>
<td>5.0</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Laboratories including equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Schools and Colleges</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classrooms</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Dormitories</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Gymnasia</td>
<td>5.0</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Laboratories including equipment</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11. Hospitals

<table>
<thead>
<tr>
<th></th>
<th>2.0</th>
<th>1.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrooms and Wards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laundries</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Toilet rooms</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>Utility rooms</td>
<td>2.0</td>
<td>4.5</td>
</tr>
<tr>
<td>X-ray room and Operating theatres</td>
<td>2.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

12. Factories

<table>
<thead>
<tr>
<th>Level</th>
<th>5.0</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>7.5</td>
<td>6.7</td>
</tr>
<tr>
<td>Heavy</td>
<td>10.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

13. Warehouses

<table>
<thead>
<tr>
<th></th>
<th>10.0</th>
<th>9.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>General storage space in industrial and commercial buildings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Note: For concentrated loads Pigeaud’s or Westergaard’s theory may be used)

17.8 Dynamic Loading

17.8.1 Where loads arising from machinery, runways, cranes and other plant producing dynamic effects are supported by or communicated to the framework, allowance shall be made for these dynamic effects, including impact, by increasing the dead-weight values by an adequate amount. In order to ensure economy in design, the appropriate dynamic increase for all members affected shall be ascertained as accurately as possible.

17.8.2 The minimum design load due to equipment, machinery on other objects or persons that may produce impact, is the total weight of equipment or machinery plus its maximum lifting capacity, or appropriate live load, multiplied by an appropriate factor listed in Table 17.7; except in cases where the actual multiplying factor has been supplied by the

(3) Sloping Roofs up to angle of 65° to the horizontal shall withstand an imposed load of 0.25kN/m² measured on plan or a vertical load of 0.9kN concentrated on a square with 300mm side whichever produces the greater stress.

(4) Curved Roofs

The imposed load on a curved roof shall be calculated by dividing the roof into not less than five equal segments and then by calculating the load on each, appropriate to its mean slope in accordance with 17.7.4(1) to 17.7.4(3).

(5) Roof coverings and purlins at a slope of less than 45° shall be capable of carrying a load of 0.9kN concentrated on any square with 125mm side.
manufacturer or supplier of the equipment in which case this factor shall be used in lieu of those listed in Table 17.7. Where dynamic effects such as resonance and fatigue are likely to be important as a result of vibration of equipment or machinery, a dynamic analysis shall be carried out.

### Table 17.7 - Impact Loads

<table>
<thead>
<tr>
<th>Impact due to</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation of motor driven cranes</td>
<td>1.25</td>
</tr>
<tr>
<td>Operation of hand driven cranes</td>
<td>1.10</td>
</tr>
<tr>
<td>Live loads on hanger supported floors and stairs</td>
<td>1.33</td>
</tr>
<tr>
<td>Supports for light machinery, shaft or motor driven</td>
<td>1.20</td>
</tr>
<tr>
<td>Supports for reciprocating machinery or power driven units</td>
<td>1.50</td>
</tr>
</tbody>
</table>

**17.8.3** The minimum horizontal design loads on cranes runway rails are:

(a) **Lateral force** which shall be:

(i) for power operated crane trolleys, 20% and for hand operated trolleys, 10% of the sum of the weights of the lifted loads and of the crane trolley excluding other parts of the crane;

(ii) applied at the top of the rail, one-half in each side of the runway, and

(iii) considered acting in either direction normal to the runway rail.

(b) **Longitudinal force** which shall be:

(i) 10 percent of the maximum wheel loads of the crane, and

(ii) applied at the top of the rail.

**17.8.4 (1) Loads on Railings**

The minimum design load applied horizontally at the top of a railing which guards a drop of more than 460mm shall be:

(a) 5.8kN/m for exterior balconies of individual residential units and a concentrated load of 0.9kN applied concurrently;

(b) 1.5kN/m for exits and stairs;

(c) 2.2kN/m for assembly occupancies, except for grandstands and stadia;

(d) 3.6kN/m for grandstands and stadia including ramps;

(e) 4.4kN/m for vehicle guard rails for parking garages applied 530mm above the roadway and minimum total load of (11kN) uniformly distributed over each vehicle space applied 530mm above the roadway, and

(f) 0.6kN concentrated load applied at any point for industrial catwalks and other areas where crowding by many people is very improbable.

(2) The minimum design load applied horizontally to panels under railings which guard a drop of more than 460mm shall be 1.0kN/m².

(3) The minimum design load applied vertically at the top of a railing which guards a drop of more than 460mm shall be 1.5kN/m acting separately from the horizontal load provided in Clause 17.8.4(1).

(4) Grandstands and any building used for assembly purposes to accommodate large numbers of people at one time shall be designed to resist all inertia sway forces produced by use and occupancy of the building or structure. The inertia force shall be not less than 0.30kN/m of seat parallel to each row of seats or 0.2kN/m of seat perpendicular to each row of seats.
17.9 EFFECTS OF WIND

17.9.1 Scope

This Subclause deals with methods for calculating wind loads that should be taken into account when designing buildings, structures and components of buildings and structures.

It does not apply to building or structures whose light weight, low frequency and low damping properties make them susceptible to vibration.

17.9.2 Definitions

Unless otherwise specified, the following definitions shall apply for the purposes of this Subclause.

1. **Breadth**: The dimension of the building normal to the direction of the wind.

2. **Depth**: The dimension of the building measured in the direction of wind.

3. **Height**: The height of a building above the ground adjoining that building.

4. **Length**: The greater horizontal dimension of a building above, the ground adjoining that building; or the length, between supports, of an individual structural member.

5. **Width**: The lesser horizontal dimension, of a building above the ground adjacent to that building, or the width of a structural member across the direction of the wind.

6. **Height above ground**: The dimension above general level of the ground to windward.

7. **Element of Surface Area**: The area of surface over which the pressure coefficient is taken to be constant.

8. **Effective Frontal Area**: The area normal to the direction of the wind or ‘shadow area’.

9. **Dynamic Pressure of Wind**: The free dynamic pressure resultant from the design wind speed.

10. **Pressure Coefficient**: The ratio of the pressure acting at a point on a surface to the dynamic pressure of the incident wind.

11. **Force Coefficient**: A non-dimensional coefficient such that the total wind force on a body is the product of the force coefficient multiplied by the dynamic pressure of the Incident wind and the appropriate area as defined in text.

12. **Topography**: The nature of the earth’s surface as influenced by the hill and valley configurations.

13. **Ground Roughness**: The nature of the earth’s surface as influenced by small-scale obstruction such as trees and buildings (as distinct from topography)

**Note**: Breadth and Depth of a building are to the direction of wind. Length and Width are dimensions related to the plan form.

17.9.3 Nomenclature

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>element of surface</td>
</tr>
<tr>
<td>$A_e$</td>
<td>effective frontal area</td>
</tr>
<tr>
<td>$b$</td>
<td>breadth</td>
</tr>
<tr>
<td>$C_f$</td>
<td>force coefficient</td>
</tr>
<tr>
<td>$C_{fn}$</td>
<td>normal force coefficient</td>
</tr>
<tr>
<td>$C_t$</td>
<td>transverse force coefficient</td>
</tr>
<tr>
<td>$C_{ft}$</td>
<td>transverse force coefficient</td>
</tr>
<tr>
<td>$C_{f1}$</td>
<td>frictional drag coefficient</td>
</tr>
<tr>
<td>$C_p$</td>
<td>pressure coefficient</td>
</tr>
<tr>
<td>$C_{pe}$</td>
<td>external pressure coefficient</td>
</tr>
<tr>
<td>$C_{pi}$</td>
<td>internal pressure coefficient</td>
</tr>
<tr>
<td>$d$</td>
<td>depth</td>
</tr>
<tr>
<td>$D$</td>
<td>diameter</td>
</tr>
<tr>
<td>$F$</td>
<td>force</td>
</tr>
</tbody>
</table>
\[ F_n = \text{normal force} \]
\[ F_t = \text{transverse force} \]
\[ F' = \text{frictional force} \]
\[ h = \text{height} \]
\[ H = \text{height above ground} \]
\[ j = \text{width of member as indicated in diagram} \]
\[ j_a = \text{width of member across direction of wind} \]
\[ k = \text{a constant} \]
\[ K = \text{reduction factor} \]
\[ l = \text{length} \]
\[ p = \text{pressure on surface} \]
\[ P_e = \text{external pressure} \]
\[ P_i = \text{internal pressure} \]
\[ B = \text{total load intensity} \]
\[ q = \text{dynamic pressure of wind (stagnation pressure)} \]
\[ R_e = \text{Reynolds number} \]
\[ S_1 = \text{topography factor} \]
\[ S_2 = \text{ground roughness, building size and height above ground factor} \]
\[ S_3 = \text{a statistical factor} \]
\[ V = \text{basic wind speed} \]
\[ V_s = \text{design wind speed} \]
\[ w = \text{width of building} \]
\[ w' = \text{bay width in multi-bay buildings} \]
\[ \alpha = \text{wind angle (from a given axis)} \]
\[ \beta = \text{aerodynamic solidity ratio} \]
\[ \eta\mu = \text{shielding factor} \]
\[ \nu = \text{kinematic viscosity} \]
\[ \varnothing = \text{geometric solidity ratio} \]

### 17.9.4 Procedure for calculating Wind Loads on Structures

(1) The wind load on a structure should be calculated for:

- a) the structure as a whole;
- b) individual structural elements such as roofs and walls;
- c) individual cladding units and their fixings.

(2) In the case of partially completed structures, the wind load will depend on the method and sequence of construction and may be critical. In calculating the temporary higher wind loads, the maximum design wind speed \( V_s \) may be assumed not to occur during the short construction period and a reduced factor \( S_3 \) used. It is recommended that the graphs of Fig.5.6 should not be extrapolated for periods less than two years.

(3) The assessment of wind load should be made as follows:

- a) The basic wind speed \( V \) appropriate to the area where the structure is to be erected is determined as specified in 5.9.5(2).
- b) The basic wind speed is multiplied by factors \( S_1, S_2 \) and \( S_3 \) to give the design wind speed \( V_s \) (see 5.9.5(3)).

\[ V_s = V S_1 S_2 S_3 \]

- c) The design wind speed is converted to dynamic pressure \( q = kV_s^2 \)

Table 17.11 gives corresponding values of \( q \) and \( V_s \)

- d) The design external pressure or suction at any point on the surface of the building is given by:

\[ p = C_p q \]
A negative value of $C_p$ indicates suction. The resultant load on an element or cladding depends on the algebraic difference of the external pressure or suction and the internal pressure or suction may be calculated from:

$$F = (C_{pe} - C_{pi})qA$$

A negative value of $F$ indicates that the resultant force is outwards.

The total wind load on a structure may be obtained by a vectorial summation of the loads on all the surfaces.

e) Where a value of force coefficient, $C_f$, is available, the total wind load on the building as a whole is more conveniently obtained from:

$$F = C_f q A$$

Pressure coefficients are given in Tables 17.14 and 17.20 for a range of building shapes. Force coefficients are given in Tables 17.21 to 17.25 for unclad structures.

### 17.9.5 Design Wind Speed, $V_s$

(1) **General:** The design wind speed $V_s$ should be calculated from

$$V_s = V S_1 S_2 S_3$$

The basic wind speed table is specified in 5.9.5(2) and the factors $S_1$, $S_2$, $S_3$ in 5.9.5(3).

(2) **Basic Wind Speed:**

a) The basic wind velocity is the maximum 3-second gust speed at a height of 10m above ground likely to be exceeded on the average not more than once in 50 years, in open country. The values are shown by *isopleths* (line of equal wind speed) on the map in Fig. 17.1. Table 17.8 gives basic wind speeds to be used in some major towns in Ghana.

b) It should be assumed the wind may blow from any direction.

#### Table 17.8 - Basic Wind Speed (in metres per second) for some major towns m/s

<table>
<thead>
<tr>
<th>Town</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accra</td>
<td>29</td>
</tr>
<tr>
<td>2. Takoradi</td>
<td>29</td>
</tr>
<tr>
<td>3. Kumasi</td>
<td>36</td>
</tr>
<tr>
<td>4. Tamale</td>
<td>34</td>
</tr>
<tr>
<td>5. Ada</td>
<td>34</td>
</tr>
<tr>
<td>6. Saltpond</td>
<td>29</td>
</tr>
<tr>
<td>7. Axim</td>
<td>29</td>
</tr>
<tr>
<td>8. Ho</td>
<td>29</td>
</tr>
<tr>
<td>9. Akuse</td>
<td>34</td>
</tr>
<tr>
<td>10. Kete – Krachi</td>
<td>38</td>
</tr>
<tr>
<td>11. Wenchi</td>
<td>38</td>
</tr>
<tr>
<td>12. Yendi</td>
<td>45</td>
</tr>
<tr>
<td>13. Wa</td>
<td>44</td>
</tr>
<tr>
<td>14. Navrongo</td>
<td>35</td>
</tr>
<tr>
<td>15. Bole</td>
<td>36</td>
</tr>
</tbody>
</table>
Fig. 17.1: Wind Speeds (m/sec)
(3) **Wind Speed Factors**

(a) **Topography Factor, \( S_1 \):** The basic wind speed, \( V \), takes account of the general level of site above sea level. This does not allow for local topographic (orographic) features such as hills, valleys, cliff escarpments or ridges, which can significantly affect the wind speed in their vicinity.

The factor \( S_1 \) is a measure of the enhancement that occurs in wind speeds over hills, cliffs and escarpments.

The effect of topography is to accelerate wind near the summit of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliffs, steep escarpments or ridges. Table 17.9 gives recommended values of \( S_1 \).

### Table 17.9 - Topography Factor \( S_1 \)

<table>
<thead>
<tr>
<th>Topography Category</th>
<th>Description</th>
<th>Value of ( S_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All cases except in 2 and 3 below</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>• Very exposed hillslopes and crests where acceleration of wind is known to occur.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Valleys shaped so that funneling of wind may occur.</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>• Sites that are known to be abnormally windy due to some local influence.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Steep sided enclosed valleys, sheltered from all winds.</td>
<td>0.9</td>
</tr>
</tbody>
</table>

(i) **Effect of a Cliff or Escarpment on the Equivalent Height above ground.**

The value of \( S_1 \) in Table 17.9 can be explicitly calculated for the effect of a cliff or escarpment at a site.

The effect of topography will be significant at a site when the upward slope (\( \theta \)) is greater than 3° (or 0.05 slope), and below that, the value of \( S_1 \) may be taken to be equal to 1.0. The value of \( S_1 \) varies between 1.0 and 1.36 for slopes greater than 3°.

The influence of the topographic feature is considered to extend 1.5\( L_e \) upwind and 2.5\( L_e \) downwind of the summit or crest of the feature, where \( L_e \) is the effective horizontal length of the hill depending on the slope as indicated in Fig. 17.2. The values of \( L_e \) for the various slopes are given in Table 17.10. If the zone downwind from the crest of the feature is relatively flat (\( \theta < 3^\circ \)) for a distance exceeding \( L_e \), then the feature should be treated as an escarpment. Otherwise, the feature must be treated as a hill or ridge.

The topography factor is given by:

\[
S_1 = 1 + C \cdot s
\]

where \( C \) has values appropriate to the height \( H \) above mean ground level and the distance \( x \) from the summit or crest relative to the effective length \( L_e \) as given in Table 17.11.
The factor, \( s \), is determined from Fig. 17.3 for cliffs and escarpments and Fig. 5.4 for ridges and hills.

Table 17.11 – Variation of effective horizontal length of hill \( L_e \) and factor \( C \), with slope, \( \theta \)

<table>
<thead>
<tr>
<th>Slope, ( \theta )</th>
<th>Effective horizontal length, ( L_e )</th>
<th>Factor, ( C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 3^\circ &lt; \theta \leq 17 )</td>
<td>( L )</td>
<td>1.2(Z/L)</td>
</tr>
<tr>
<td>&gt;17°</td>
<td>( Z/0.3 )</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Note: \( L \) is the actual length of the upwind slope in the wind direction, and \( Z \) is the effective height of the feature.

Fig. 17.2a: Topographical dimensions – General notations
Fig. 17.2: Topographical dimensions – (a) Hill and Ridge, (b) Cliff and Escarpment
Fig. 17.5: Categories of Ground Roughness

(b) Ground Roughness, Building Size and Height above ground, Factor $S_2$

The effect of wind on a building, structure or part thereof depends on ground roughness variation of wind with height above ground and size of building or component under consideration. The
factor \( S_2 \) takes account of the influences on wind effect listed above.

(i) Ground Roughness

The ground roughness has been divided into three categories and buildings and their elements into three classes as follows:

**Ground Roughness 1**: Open, level or nearly level country with no obstructions.

Examples are most of the coastal region outside major urban and sub-urban areas, air fields and areas surrounding the Volta Lake.

**Ground Roughness 2**: Open country with few trees and houses. Examples are farmland and most of the areas of the North and Upper Regions outside major urban centres.

**Ground Roughness 3**: Areas covered by large obstructions. Examples are forest areas, towns and their suburbs. Fig. 5.5 shows areas of the country outside major towns and suburbs where the different categories should be generally applicable.

(ii) Cladding and Building size

Natural winds are turbulent and continually fluctuating. There is evidence available that for buildings and components of buildings more susceptible to the action of wind, the 3-second gust speed should be used in design while for other buildings a longer averaging time could be used. As a consequence of this, 3 classes have been selected.

**Class A**: All units of cladding, glazing and roofing and their immediate fixings and individual members of unclad structures.

**Class B**: All buildings and structures where neither the greatest horizontal dimension nor the greatest vertical dimension exceeds 50m.

**Class C**: All buildings and structures whose greatest horizontal dimension or greatest vertical dimension exceeds 50m.

The value of \( S_2 \) for variation for wind speed with height above ground for various ground roughness categories and building size classes are given in Table 17.12. The height to be used for the determination of \( S_2 \) should be taken as the height from the mean ground level adjoining the building to the top of the building. Alternatively, the structure may be divided into convenient parts and wind load on each part calculated, using \( S_2 \) factor that corresponds to the height above ground of the top of the part. The dynamic pressure should be assumed to act uniformly over the structure or part respectively.

(c) Factor for building life, \( S_3 \)

The factor \( S_3 \) takes into account the intended life-span of the building or structure and the acceptable calculated risk. There is always an element of risk that a given design wind speed may be exceeded in a storm of exceptional violence. The greater the life-span of the structure, the greater the risk. Fig. 17.6 shows values of \( S_3 \) equivalent to a period of exposure of 50 years plotted against intended life span or design life in years.

Normally, wind loads on completed structures and buildings should be calculated at \( S_3 = 1 \) except for:

(i) temporary structures;

(ii) structures where a longer period of exposure to wind may be required;

(iii) structures where greater than normal safety is required.

The period of exposure should never be taken as less than 2 years.

Example: Calculate the design speed for a tower 20m high, situated in a well wooded area (roughness category 3) and for 100-year probable life near an abrupt escarpment of height 35m. The tower is located around Ho. The crest of the escarpment is 10m effective distance from the plains. The tower is located on the downwind side, 5m from the crest.

\[
\tan \theta = \frac{10}{35} = 0.2857, \quad \theta = 15.74^\circ
\]

\[
X = +5 \quad L_e = 10m \quad H = 20m \quad \frac{X}{L_e} = +5/10 = +0.5 \quad \frac{H}{L_e} = 20/10 = 2
\]

Basic wind speed for Ho, \( V = 29m/s \) (Fig. 5.1, Table 17.8)
561

S₃ factor for 100 yr probable life with probability level of 0.63 = 1.05 (Fig. 17.6)

S₂ factor for 20m for a well–wooded area (ground roughness category 3)(Class B) = 0.90 (Fig. 17.5, Table 17.12)

S₁ factor for topography:
For X/Lₑ = +0.5 and H/Lₑ = 2 (Fig. 5.2); s factor from Fig. 5.3 is = 0.05

From Table 17.11, factor C = 1.2Z/Lₑ = 1.2x20/10 = 2.4

→ S₁ = 1 + C x s = 1 + 0.05 x 2.4 = 1.12

→ Design wind speed = Vₛ = V x S₁ x S₂ x S₃ = 29

(1.12)(0.9)(1.05) = 30.7 m/s

**Fig 17.5 - Factor for building life, S₃**

Note on Fig. 17.6

For example, using the graph for probability level 0.63 for a period of exposure equal to 100 years say, S₃ = 1.05 i.e. there is the probability level of 0.63 that a speed which is 1.05 times the once in 50 years wind speed obtained from Fig. 5.1 will be exceeded at least once in 100 years.

**17.9.6 Dynamic Pressure of the Wind**

Using the value of the design speed Vₛ obtained from clause 5.9.5, the dynamic pressure of the wind q above atmospheric pressure may be calculated from

\[ q = k Vₛ² \]

Where: \( k = 0.613 \) in SI units (N/m and m/s)

Table 17.13 gives corresponding values of \( Vₛ \) and q.
### Table 17.12 - Ground Roughness, Building size and Height above ground, Factor $S_2$

<table>
<thead>
<tr>
<th>H (m)</th>
<th>1. Open Country with no obstructions</th>
<th>2. Open Country with few trees and houses</th>
<th>3. Towns, Suburbs, Forest areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class</td>
<td>Class</td>
<td>Class</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>3 or less</td>
<td>0.83</td>
<td>0.78</td>
<td>0.73</td>
</tr>
<tr>
<td>5</td>
<td>0.88</td>
<td>0.83</td>
<td>0.78</td>
</tr>
<tr>
<td>10</td>
<td>1.00</td>
<td>0.95</td>
<td>0.90</td>
</tr>
<tr>
<td>15</td>
<td>1.03</td>
<td>0.99</td>
<td>0.94</td>
</tr>
<tr>
<td>20</td>
<td>1.06</td>
<td>1.01</td>
<td>0.96</td>
</tr>
<tr>
<td>30</td>
<td>1.09</td>
<td>1.05</td>
<td>1.00</td>
</tr>
<tr>
<td>40</td>
<td>1.12</td>
<td>1.08</td>
<td>1.03</td>
</tr>
<tr>
<td>50</td>
<td>1.14</td>
<td>1.10</td>
<td>1.06</td>
</tr>
<tr>
<td>60</td>
<td>1.15</td>
<td>1.12</td>
<td>1.08</td>
</tr>
<tr>
<td>80</td>
<td>1.18</td>
<td>1.15</td>
<td>1.11</td>
</tr>
<tr>
<td>100</td>
<td>1.20</td>
<td>1.17</td>
<td>1.13</td>
</tr>
<tr>
<td>120</td>
<td>1.22</td>
<td>1.19</td>
<td>1.15</td>
</tr>
<tr>
<td>140</td>
<td>1.24</td>
<td>1.20</td>
<td>1.17</td>
</tr>
<tr>
<td>160</td>
<td>1.25</td>
<td>1.22</td>
<td>1.19</td>
</tr>
<tr>
<td>180</td>
<td>1.26</td>
<td>1.23</td>
<td>1.20</td>
</tr>
<tr>
<td>200</td>
<td>1.27</td>
<td>1.24</td>
<td>1.21</td>
</tr>
</tbody>
</table>

### Table 17.13 - Values of $q$ in SI Units (N/m²)

<table>
<thead>
<tr>
<th>$V_s$ (m/s)</th>
<th>0</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>6.0</th>
<th>7.0</th>
<th>8.0</th>
<th>9.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>61</td>
<td>74</td>
<td>88</td>
<td>104</td>
<td>120</td>
<td>138</td>
<td>157</td>
<td>177</td>
<td>199</td>
<td>221</td>
</tr>
<tr>
<td>20</td>
<td>245</td>
<td>270</td>
<td>297</td>
<td>324</td>
<td>353</td>
<td>383</td>
<td>414</td>
<td>447</td>
<td>481</td>
<td>516</td>
</tr>
<tr>
<td>30</td>
<td>552</td>
<td>589</td>
<td>628</td>
<td>668</td>
<td>709</td>
<td>751</td>
<td>794</td>
<td>839</td>
<td>885</td>
<td>932</td>
</tr>
<tr>
<td>40</td>
<td>981</td>
<td>1030</td>
<td>1080</td>
<td>1130</td>
<td>1190</td>
<td>1240</td>
<td>1300</td>
<td>1350</td>
<td>1410</td>
<td>1470</td>
</tr>
</tbody>
</table>
50  1530  1590  1660  1720  1790  1850  1920  1990  2060  2130
60  2210  2280  2360  2430  2510  2590  2670  2750  2830  2920
70  3000

(Note: To determine q for a speed of say 33 m/s look under 3 along the row corresponding to 30 which gives q = 668 N/m²).

17.9.7 Pressure Coefficients and Force Coefficients

(1) General: The force on a building or structure or part thereof is obtained by multiplying the dynamic pressure by a coefficient that is dependent on the shape of the building or structure and by the area of the building or structure or part thereof.

The two types of coefficients are:

(a) pressure coefficient \( C_p \) which refers to a particular surface or part of building;

(b) force coefficient \( C_f \) which refers to the building as a whole. The values of these coefficients are given in Tables 5.14 to 5.23. These tables may be used for other buildings of generally similar shape.

(2) Pressure Coefficients: The average values given in the tables are for critical wind directions in one or more quadrants. In order to determine the maximum wind load on a building the total load should be calculated from each of the surfaces or parts of the surfaces of the building. Coefficients of local effects are also given. These are to be used in calculating loads for local areas but not for calculating the load on entire structural elements such as roof and walls. In such locations, the construction must be adequate to resist the local forces (additional nailing, anchoring etc.).

Furthermore, it should be noted that these local forces can act in a shaking manner and result in fatigue failures. The net design load due to wind on individual cladding and their fixings, roofs and walls should be the algebraic difference of the external pressure or suction and the design internal pressure or suction from:

\[
F = (C_{pe} - C_{pi}) qA
\]

Values of \( C_{pe} \) are given in Tables 5.14, 5.15, 5.16 and values of \( C_{pi} \) in clause 5.9.7(3).

(3) Internal Pressure Coefficient: It is normally difficult to estimate the internal pressure coefficient for a building as the coefficient depends on permeability through windows, ventilation louvres, leakage gaps around doors and windows and cladding. It is recommended that for wall and roof loading the internal pressure coefficient should be determined as follows:

(a) Where there is only negligible probability of dominant opening occurring during a severe storm, \( C_{pi} \) should be taken as +0.2 or -0.3 whichever produces the greater effect on the building or member concerned.

(b) Where a dominant opening is likely to occur, \( C_{pi} \) should be taken as 7.5% of the value of \( C_{pe} \) outside the opening.

(4) Force Coefficients: Force coefficients vary for the wind acting on different faces of a building or structure. In determining the critical load, the total wind load should be calculated for
each wind direction. The total wind load on a particular building or structure is given by:

\[ F = C_l q A_e \]

The direction of the force is specific in the table.

Where the wind load is calculated by dividing the area into parts, the value of \( C_l \) applied to each part should be that for the building as a whole.

\[ F = C_l q A_e \]

Where the wind load is calculated by dividing the area into parts, the value of \( C_l \) applied to each part should be that for the building as a whole.

6. Frictional Drag: For certain types of buildings it is necessary to take into account a frictional drag in addition to the wind load calculated from 5.9.7(2) and 5.9.7(4). The frictional drag may be neglected for rectangular clad buildings where the ratio \( d/h \) or \( d/b \) is greater than 4. The frictional drag in the direction of the wind is given by the following:

If \( h \leq b \),

\[ F' = C_{f'} q b(d - 4h) + C_{f'} 2h (d - 4h) \]

or

If \( h \geq b \),

\[ F' = C_{f'} q b(d - 4b) + C_{f'} 2h (d - 4h) \]

The first term in each formula represents the drag on the roof and the second the drag on the walls.

\[ C_{f'} = 0.01 \] for smooth surfaces without corrugations or ribs across the wind direction.

\[ C_{f'} = 0.02 \] for surfaces with ribs across the wind direction.

\[ 0. C_{f'} = 0.04 \] surfaces with ribs across the wind direction.

For other buildings the frictional drag will be indicated, where necessary, in tables of pressure coefficients and force coefficients.

Table 17.14: Pressure coefficient \( C_{pe} \) for walls of Rectangular clad buildings

<table>
<thead>
<tr>
<th>BUILDING HEIGHT RATIO</th>
<th>BUILDING PLAN RATIO</th>
<th>ELEVATION PLAN</th>
<th>WIND ANGLE ( \theta \circ )</th>
<th>Cpe for surface</th>
<th>Local Cpe</th>
</tr>
</thead>
<tbody>
<tr>
<td>h/w ≤ ( \frac{1}{2} )</td>
<td>1&lt;( l/w )≤ ( \frac{3}{2} )</td>
<td>C</td>
<td>0</td>
<td>90</td>
<td>+0.7</td>
</tr>
<tr>
<td>h/w ≤ ( \frac{3}{2} )</td>
<td>3/2&lt;( l/w )≤ ( 4 )</td>
<td>C</td>
<td>0</td>
<td>90</td>
<td>+0.7</td>
</tr>
<tr>
<td>1/2&lt;h/w≤3/2</td>
<td>1&lt;( l/w )≤ ( \frac{3}{2} )</td>
<td>C</td>
<td>0</td>
<td>90</td>
<td>+0.7</td>
</tr>
</tbody>
</table>

564
<table>
<thead>
<tr>
<th>$3/2 &lt; l/w \leq 4$</th>
<th>$h/w \leq 6$</th>
<th>$l/w = 3/2$</th>
<th>$a$</th>
<th>$C$</th>
<th>$0$</th>
<th>$90$</th>
<th>$+0.7$</th>
<th>$-0.5$</th>
<th>$-0.3$</th>
<th>$-0.7$</th>
<th>$-0.7$</th>
<th>$1.1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 &lt; l/w \leq 3/2$</td>
<td>$h/w &gt; 6$</td>
<td>$l/w = 1$</td>
<td>$a$</td>
<td>$C$</td>
<td>$0$</td>
<td>$90$</td>
<td>$+0.8$</td>
<td>$-0.8$</td>
<td>$-0.25$</td>
<td>$-0.8$</td>
<td>$-0.8$</td>
<td>$1.2$</td>
</tr>
<tr>
<td>$3/2 &lt; l/w \leq 4$</td>
<td>$l/w = 2$</td>
<td>$a$</td>
<td>$C$</td>
<td>$0$</td>
<td>$90$</td>
<td>$+0.7$</td>
<td>$-0.5$</td>
<td>$-0.4$</td>
<td>$-0.7$</td>
<td>$-0.7$</td>
<td>$1.2$</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** $h$ is the height to eaves or parapet, $l$ is the greater horizontal dimension of a building and $w$ is the lesser horizontal dimension of a building.
Fig. 17.15: External pressure coefficients ($C_{pe}$) for Pitched roofs of rectangular clad buildings

<table>
<thead>
<tr>
<th>Building Height Ratio</th>
<th>Roof Angle $\alpha$</th>
<th>Wind angle $\theta$ $^0$</th>
<th>Wind angle $\theta$ $90^0$</th>
<th>Local Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Degrees</td>
<td>EF</td>
<td>GH</td>
<td>EG</td>
</tr>
<tr>
<td>h ≤ $\frac{1}{2}$ w</td>
<td>0</td>
<td>-0.8</td>
<td>-0.4</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-0.9</td>
<td>-0.4</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>-1.2</td>
<td>-0.4</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>-0.4</td>
<td>-0.4</td>
<td>-0.7</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0</td>
<td>-0.4</td>
<td>-0.7</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>+0.3</td>
<td>-0.5</td>
<td>-0.7</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>+0.7</td>
<td>-0.5</td>
<td>-0.7</td>
</tr>
<tr>
<td>$\frac{1}{2}$ ≤ h $\leq \frac{3}{2}$ w</td>
<td>0</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-1.0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-0.9</td>
<td>-0.6</td>
<td>-0.9</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>-1.1</td>
<td>-0.6</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>-0.2</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>+0.2</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>+0.6</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td>$\frac{3}{2}$ ≤ h $\leq 6$ w</td>
<td>0</td>
<td>-0.7</td>
<td>-0.6</td>
<td>-0.9</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-0.7</td>
<td>-0.6</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>-0.7</td>
<td>-0.6</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>-0.8</td>
<td>-0.6</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>-1.0</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>-0.2</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>+0.2</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>+0.5</td>
<td>-0.5</td>
<td>-0.8</td>
</tr>
</tbody>
</table>
NOTE 1 - $h$ is the height to eaves or parapet and $w$ is the lesser plan dimension of a building.

NOTE 2 - Where no local coefficients are given, the overall coefficients apply.

NOTE 3 - For hipped roofs the local coefficient for the hip ridge may be conservatively taken as the central ridge value.

**Table 17.16:**

- **Y** = $h$ or $0.15 \times W$, whichever is the smaller

567
Pressure coefficient $C_{fe}$ for monopitch Roofs of rectangular clad buildings with $h/w < 2$

Table 17.17: Force coefficients ($C_f$) for Rectangular clad (acting in the direction of the wind)
Table 17.18: Pressure coefficients (Cpe) for Pitched Roofs of Multi-span buildings
(all spans equal) with $h \leq w$
Table 17.19: Pressure coefficients ($C_{pe}$) for Saw-tooth Roofs of multi-span buildings (all spans equal) with $h \leq w$
### Table 17.20: Pressure coefficients ($C_p$) for Canopy Roofs with $1/2 \leq h/w < 1$

<table>
<thead>
<tr>
<th>Section</th>
<th>Roof angle</th>
<th>Windward slope</th>
<th>Leeward slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>degrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-0.8 or +1.2</td>
<td>-1.0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>-0.6 or +1.4</td>
<td>-1.0</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>-0.4 or +1.6</td>
<td>-1.0</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>-0.2 or +1.8</td>
<td>-0.7</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0 or +2.0</td>
<td>-0.2</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>0 or +2.0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The coefficients take account of the combined effect of the wind on both upper and lower surfaces of the canopy. Where alternative coefficients are given the canopy should be designed to accept both loading conditions. In addition to the uplift forces, there will be horizontal loads on the canopy due to the wind pressure on any facia and to wind friction over the surface of the roof. For any wind direction, only one of these two, the more onerous, need be taken into account. Facia loads should be calculated on the area of the surface facing the wind, using a force coefficient of 1.3.

Frictional drag should be calculated using the coefficient given in 7.4 $C_{dp}$ for individual cladding panels should be taken as +2.0.

For monopitch canopies the centre of pressure should be taken as acting at 0.25 of the span from the windward edge. For double pitch canopies the centre of the pressure should be taken as acting at the midpoint of each slope.

### Table 17.21: Force coefficient ($C_f$) for clad buildings of uniform clause

572
(acting in direction of wind)

<table>
<thead>
<tr>
<th>Plan Shape</th>
<th>$V_p b$ m$^2$/s</th>
<th>$C_f$ for Height / Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\leq 2$</td>
</tr>
<tr>
<td>Wind $V_2$</td>
<td>$&lt; 6$</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>$\geq 6$</td>
<td></td>
</tr>
<tr>
<td>Rough or with projections</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Smooth</td>
<td>$\geq 6$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$&lt; 10$</td>
<td>0.5</td>
</tr>
<tr>
<td>Ellipse $b/d = 1/2$</td>
<td>$\geq 10$</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>$&lt; 8$</td>
<td>0.9</td>
</tr>
<tr>
<td>Ellipse $b/d = 2$</td>
<td>$\geq 8$</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>$&lt; 4$</td>
<td>0.6</td>
</tr>
<tr>
<td>Square $r/b = 1/3$</td>
<td>$\geq 4$</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>$&lt; 10$</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>$\geq 10$</td>
<td>0.5</td>
</tr>
<tr>
<td>Square $r/b = 1/6$</td>
<td>$&lt; 3$</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>$\geq 3$</td>
<td>0.2</td>
</tr>
<tr>
<td>Square $r/b = 1/2$</td>
<td>$&lt; 3$</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>$\geq 3$</td>
<td>0.2</td>
</tr>
<tr>
<td>Square $r/b = 1/6$</td>
<td>$&lt; 8$</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 17.21 (cont.)
<table>
<thead>
<tr>
<th>( r_d = \frac{1}{12} )</th>
<th>( r_d = % )</th>
<th>( r_b = 1.4 )</th>
<th>( r_b = 1.3 )</th>
<th>( r_b = 1.2 )</th>
<th>( \theta = 2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>All values</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>9.6</td>
<td>9.5</td>
</tr>
<tr>
<td>0.8</td>
<td>0.4</td>
<td>0.7</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>1.1</td>
<td>0.5</td>
<td>0.6</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>1.4</td>
<td>1.2</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

*Note: The table contains dimension values for different shapes, likely part of a design or engineering guide.*
### Table 17.21 (cont.)

<table>
<thead>
<tr>
<th>Shape</th>
<th>Condition</th>
<th>All Values</th>
<th>0.8</th>
<th>1.0</th>
<th>1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangle</td>
<td>r/b = 1/48</td>
<td>All Values</td>
<td>0.8</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>&lt; 8</td>
<td></td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>≥ 8</td>
<td></td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Rectangle</td>
<td>1/48 &lt; r/b &lt; 1/2</td>
<td>All Values</td>
<td>1.2</td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Octagon</td>
<td></td>
<td>All values</td>
<td>1.1</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Hexagon</td>
<td></td>
<td>All values</td>
<td>1.2</td>
<td>1.4</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Structures that are in the supercritical flow regime because of their size and design wind speed, may need further calculation to ensure that the greatest loads do not occur at some wind speed below the maximum when the flow will be sub-critical.

The coefficients are for buildings without projections, except where otherwise shown. In this table $V_b$ is used as an indication of the airflow regime.
Table 17.22: Pressure distribution around Cylindrical structures

For the purpose of calculating the wind forces that act in a way as to deform a cylindrical structure the values of $C_{pe}$ in Table 17.22 may be used. They apply only in supercritical flow (i.e. they should only be used where $D > 0.3m$). They may be used for wind blowing normal to the axis of cylinders having their axis normal to the ground plane (i.e. chimneys, silos) and to cylinders having their axis parallel with the ground plane (i.e. horizontal tanks) provided the clearance between the tank and the ground is not less than $D$.

$h$ is the height of a vertical cylinder or length of a horizontal cylinder. Where there is a free flow of air around both ends, $h$ is to be taken as half the length when calculating $h/D$. Interpolation may be used for intermediate values of $h/D$.

In the calculation of the load
on the periphery of the cylinder, the value $C_{pi}$ shall be taken into account.

For open ended cylinders where $h/D \geq 0.3$; $C_{pi}$ may be taken as -0.8.

For open ended cylinders where $h/D \leq 0.3$; $C_{pi}$ may be taken as -0.5

17.9.8 Force Coefficients for Un clad Structures

(1) **General:** This clause applies to permanently unclad structures and structural frameworks while temporarily unclad.

Structures that because of their size and the design wind velocity, are in the supercritical flow regime may need further calculation to ensure that the greatest loads do not occur at some wind speed below the maximum when the flow will be subcritical.

(2) **Force coefficients of individual members:** The coefficients refer to members of infinite length. For members of finite length, the coefficients should be multiplied by a factor $K$ that depends on the ratio $l/j_a$ where $l$ is the length of the member and $j_a$ is the width across the direction of the wind. Values of $K$ are given in Table 17.23.

Where any member abuts onto a plate or wall in such a way that free flow of air around that end of the member is prevented, the ratio $l/j_a$ should be doubled for the purpose of determining $K$. When both ends of a member are so obstructed, the ratio should be taken as infinity.

Table 17.23 - Values of Reduction Factor K for members of finite length and slenderness

<table>
<thead>
<tr>
<th>$l/j_a$ or $I/D$</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>40</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular cylinder, subcritical flow</td>
<td>0.58</td>
<td>0.62</td>
<td>0.68</td>
<td>0.74</td>
<td>0.82</td>
<td>0.87</td>
<td>0.98</td>
</tr>
<tr>
<td>Circular cylinder, supercritical flow</td>
<td>0.80</td>
<td>0.80</td>
<td>0.82</td>
<td>0.90</td>
<td>0.98</td>
<td>0.99</td>
<td>1.0</td>
</tr>
<tr>
<td>Flat plate perpendicular to wind</td>
<td>0.62</td>
<td>0.68</td>
<td>0.69</td>
<td>0.81</td>
<td>0.87</td>
<td>0.90</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Normal force: $F = C_{fn} q_{klj}$

Transverse force: $F = C_{ft} q_{klj}$

17.9.8(3) (a) **Flat-sided members:** The force coefficient in Table 17.24 are given for two mutually-perpendicular directions relative to a reference axis on the structural member. They are designated $C_{fn}$ and $C_{ft}$ and give the forces normal and transverse, respectively, to the reference plane as will be apparent from the diagrams.

Force coefficients are for wind normal to the longitudinal axis of the member.

(b) **Circular clauses:** For circular clauses, the force coefficients $C_i$, which are dependent upon values of $DV_s$, are given in Table 17.25. The values of $C_i$ given in this table are suitable for all surfaces of evenly distributed roughness of height less than 1/100 diameter i.e. for all normal surface finishes and for members of infinite length.

Force, $F = C_i q_{kil}$
Table 17.24: Force coefficients $C_{fn}$ and $C_{ft}$ for individual structural members (flat sides) of infinite length.
Table 17.25 - Force Coefficients \( C_f \) for individual structural members of Circular Clause and Infinite Length

<table>
<thead>
<tr>
<th>Flow regime</th>
<th>Force coefficient ( C_f )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subcritical flow</strong></td>
<td>1.2</td>
</tr>
<tr>
<td>( DV_s &lt; 6m^2/s )</td>
<td></td>
</tr>
<tr>
<td>( Re \leq 4.1 \times 10^5 )</td>
<td></td>
</tr>
<tr>
<td><strong>Supercritical flow</strong></td>
<td></td>
</tr>
<tr>
<td>( 6 \leq DV_s &lt; 12m^2/s )</td>
<td>0.6</td>
</tr>
<tr>
<td>( 4.1 \times 10^5 \leq Re &lt; 8.2 \times 10^5 )</td>
<td>\n</td>
</tr>
<tr>
<td>( 8.2 \times 10^5 \leq Re &lt; 22.6 \times 10^5 )</td>
<td>\n</td>
</tr>
</tbody>
</table>
| \( Re \geq 22.6 \times 10^5 \) | \n
Reynolds number, \( Re > \frac{DV_s}{\nu} \)

where: \( D \) is the diameter of the member, \( v \) is the Kinematic viscosity of the air, which is \( 1.6 \times 10^{-5} \) m\(^2\)/s at 15°C and standard atmospheric pressure.

(c) **Wires and cables**: The force coefficients for wires and cables given in Table 17.26 are dependent upon values of \( DV_s \).

Table 17.26 - Force Coefficients \( C_f \) for Wires and Cables (1/D >100)

<table>
<thead>
<tr>
<th>Flow Regime</th>
<th>Smooth surface wire</th>
<th>Moderately wire (galvanized or painted)</th>
<th>Fine stranded cables</th>
<th>Thick stranded cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>( DV_s &lt; 0.6m^2/s )</td>
<td>-</td>
<td>-</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>( DV_s \geq 0.6m^2/s )</td>
<td>1.2</td>
<td>1.2</td>
<td>0.9</td>
<td>1.1</td>
</tr>
<tr>
<td>( DV_s &lt; 6m^2/s )</td>
<td>0.5</td>
<td>0.7</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>( DV_s \geq 6m^2/s )</td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

(4) **Single frames**: In general, the most unfavourable wind load on a single frame occurs when the wind is at right angles to the frame.
The wind load acting on a single frame should be taken as

\[ F = C_f q Ae \]

where; \( Ae \) is the effective area of frame normal to the wind direction.

The force coefficients for a single frame consisting of (a) flat-sided members or (b) circular clause members in which all the members of the frame have \( DV_s \) value less or greater than \( 6\text{m}^2/\text{s} \) are given in Table 17.27.

**Table 17.27 - Effective Force Coefficients \( C_f \) for Single Frames**

<table>
<thead>
<tr>
<th>Solidity ratio ( \Phi )</th>
<th>Force coefficient ( C_f ) for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flat – sided members</td>
</tr>
<tr>
<td></td>
<td>Subcritical flow</td>
</tr>
<tr>
<td></td>
<td>( DV_s \leq 6\text{m}^2/\text{s} )</td>
</tr>
<tr>
<td>0.1</td>
<td>1.9</td>
</tr>
<tr>
<td>0.2</td>
<td>1.8</td>
</tr>
<tr>
<td>0.3</td>
<td>1.7</td>
</tr>
<tr>
<td>0.4</td>
<td>1.7</td>
</tr>
</tbody>
</table>

The solidity ratio \( \Phi \) is equal to the effective area of a frame normal to the wind direction divided by the area enclosed by the boundary of the frame normal to the wind direction.

(5) **Multiple frame structures**: This clause applies to structures having two or more parallel frames where the windward frame may have a shielding effect upon the frames to leeward. The wind load on the windward frame and any unsheltered parts of other frames should be calculated as in 5.9.8(3), but wind load on the parts of frames that are sheltered should be multiplied by a shielding factor \( n \), which is dependent upon the solidity ratio of the windward frame, the type of member comprising the frame and the spacing ratio of the frames. The values of the shielding factor are given in Table 17.28.

Where there are more than two frames of similar geometry and spacing, the wind load on the third and subsequent frames should be taken as equal to that on the second frame.

**Table 17.28 - Shielding Factor, \( n \)**

<table>
<thead>
<tr>
<th>Spacing Ratio</th>
<th>Value of ( n ) for an aerodynamic solidity ratio of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Up to 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3.0</td>
<td>1.0</td>
</tr>
<tr>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>5.0</td>
<td>1.0</td>
</tr>
<tr>
<td>6.0 and over</td>
<td>1.0</td>
</tr>
</tbody>
</table>
The spacing ratio is equal to the distance, centre to centre, of the frames, beams or girders divided by the least overall dimension of the frame, beam or girder measured at right angles to the direction of the wind.

Aerodynamic solidity ratio, \( \beta = \text{solidity ratio} (\Theta) \times \text{a constant} \)

where the constant is:

- 1.6 for flat-sided members;
- 1.2 for circular clauses in the subcritical range and for flat-sided members in conjunction with such circular clauses;
- 0.5 for circular clauses in the supercritical range and for flat-sided members in conjunction with circular clauses.

(6) **Lattice Towers:**

(a) Lattice towers of square and equilateral triangular clauses constitute special cases for which it is convenient to use overall force coefficient in the calculation of wind load. The wind load should be calculated for the condition when the wind blows against any face.

The wind load acting in the direction of the wind should be taken as:

\[ F = C_f q A_e \]

The overall force coefficient \( C_f \) is given in Tables 5.29, 5.30 and 5.31.

**Table 17.29 - Overall Force Coefficient \( C_f \) for Towers composed of Flat-sided members**

<table>
<thead>
<tr>
<th>Solidity ratio</th>
<th>Force coefficient of for:</th>
<th>Square towers</th>
<th>Equilateral triangular towers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>3.8</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>3.3</td>
<td>2.7</td>
<td></td>
</tr>
</tbody>
</table>

For square lattice towers the maximum load occurs when the wind blows on to a corner. It may be taken as 1.2 times the load for the face-on wind. For triangular lattice towers the wind load may be assumed to be constant for any inclination of the wind to face.

(b) Since it is only in very few cases with lattice towers composed of members of circular clause that all the members of a lattice tower are entirely in either subcritical or supercritical flow, wind force calculations should be carried out as described in 5.9.8(4) for single frames, due account being taken of the shielding factors in 5.9.8(5).

When it can be shown that all the members of the tower are wholly in the same flow regime the overall force coefficients \( C_f \) given in Tables 5.29 and 5.30 may be used. Solidity ratio of a frame = \( \Theta \). For lattice steel towers, \( \Theta \) typically varies between about 0.1 and 0.3

\[ \phi = \frac{\text{Shaded area}}{\text{Area} \ abcd} \]

**Table 17.30 - Overall Force Coefficient \( C_f \) for Square Towers composed of Rounded Members**

<table>
<thead>
<tr>
<th>Solidity ratio of front face, ( \Theta )</th>
<th>Force coefficient ( C_f ) for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcritical flow</td>
<td>Supercritical flow</td>
</tr>
</tbody>
</table>
### Table 17.31 - Overall Force Coefficient $C_f$ for Equilateral Triangular Towers composed of Rounded members

<table>
<thead>
<tr>
<th>Solidity ratio of front face, $\varnothing$</th>
<th>Force coefficient of for:</th>
<th>Subcritical flow</th>
<th>Supercritical flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV $&lt; 6m^2$/s (45ft mile/h)</td>
<td>DV $\geq 62$/s (45ft mile/h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>onto face</td>
<td>onto corner</td>
<td>onto face</td>
<td>onto corner</td>
</tr>
<tr>
<td>0.05</td>
<td>2.4</td>
<td>2.5</td>
<td>1.1</td>
</tr>
<tr>
<td>0.1</td>
<td>2.2</td>
<td>2.3</td>
<td>1.2</td>
</tr>
<tr>
<td>0.2</td>
<td>1.9</td>
<td>2.1</td>
<td>1.3</td>
</tr>
<tr>
<td>0.3</td>
<td>1.7</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>0.4</td>
<td>1.6</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td>0.5</td>
<td>0.4</td>
<td>1.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

### 17.10 EFFECTS OF EARTHQUAKES

#### 17.10.1 SCOPE AND FIELD OF APPLICATION

17.10.1.1 This Code sets down minimum design requirements to be met when dealing with seismic situations i.e. situations in which the earthquake action is considered as a critical action in conjunction with other dead loads or live loads. It applies to:

1. Reinforced and Prestressed concrete buildings for ordinary uses, having structural resisting systems belonging to one of three types defined below:
   
   (a) **Frame System**: A system in which both vertical loads and lateral forces are resisted by space frames.
   
   (b) **Wall System**: A system in which both vertical loads and lateral forces are resisted by structural walls either single or coupled.
   
   (c) **Dual System**: A system in which support for vertical load is essentially provided by a space frame. Resistance to lateral action is contributed to, in part, by the frame system and also in part by structural walls, isolated or coupled.

#### 17.10.2 DEFINITIONS AND NOTATIONS

**Definitions**

**Cross-tie**: A continuous bar with a minimum diameter of 6mm, having a $135^0$ hook with a ten-diameter extension at one end, and a $90^0$ hook with a six diameter extension at the other end. The hooks shall engage hoop bars and be secured to longitudinal bars.

**Hoop**: A closed tie or continuously would tie with a minimum diameter of 6mm the ends of which have $135^0$ hooks with ten-diameter extensions that encloses the longitudinal reinforcement.

**Boundary elements**: Portions along the edges of walls and diaphragms strengthened by longitudinal and transverse reinforcement. Boundary elements do not necessarily require an increase of thickness of the wall or diaphragms. Edge openings within walls and
diaphragms may also have to be provided with boundary elements.

**Notations**

- $A$ = peak ground acceleration
- $A_c$ = confined area measured to outside peripheral transverse reinforcement.
- $A_g$ = gross clauseal area of concrete
- $C_d$ = design seismic coefficient
- $C_g$ = centre of mass
- $C_k$ = centre of stiffness
- $E$ = design seismic action (symbolic)
- $I$ = importance factor
- $M_{ud}$ = ultimate moment of a concrete clause, evaluated with factored values of concrete and steel strengths
- $M'_{ud}$ = ultimate moment of a concrete clause, evaluated with characteristic values of concrete and steel strengths.
- $N_d$ = design axial force under the most unfavourable load combination including the seismic action.
- $K$ = behaviour factor
- $S$ = site coefficient
- $S_i$ = soil type index
- $V_{cd}$ = shear force carried by concrete in beam or column clauses
- $a$ = plan dimension of the building in the direction orthogonal to that of seismic action
- $b_w$ = web width of a concrete clause
- $h,b$ = height and width of beams, major and minor sides in columns
- $h', b'$ = distance between reinforcement bars located at the ends of sides in and b, respectively, measured to outside the peripheral bars
- $d$ = distance from centre of stiffness and centre of gravity of the generic floor
- $S_h$ = spacing of transverse reinforcement in beams, columns and walls.
- $f_{cd}$ = design concrete strength
- $h$ = height of a floor
- $l_w$ = horizontal wall length
- $h_w$ = total wall length
- $h_n$ = vertical distance between floors in walls
- $\alpha$ = spectral amplification factor
- $\beta$ = parameter of the elastic response spectrum
- $\eta$ = distribution factor
- $\gamma_n$ = over-capacity factor
- $\Delta_{el}$ = elastic interstorey drift under the seismic actions
- $\zeta$ = ratio between maximum and minimum shear force at a beam end
- $\varnothing$ = deformability index
- $\xi$ = amplification factor for torsional effects
- $w$ = dynamic magnification factor
- $\tau_{rd}$ = shear design stress of concrete

17.10.3 DESIGN CRITERIA

17.10.3.1 Reliability Differentiation

Structures shall be classified under the following reliability levels:

1. **Class I**: Buildings that are required to remain functional and to suffer reduced damage after a strong seismic attack (e.g. essential rescue facilities such as hospitals, fire and police stations, electricity stations etc. buildings with likely large number of occupants such as schools, audience or spectacle halls, etc).
(2) **Class II:** Buildings not included in 5.10.3.1

(3) The different reliability levels proper to each Class shall be obtained by amplifying the design action with a factor I, called importance factor.

### 17.10.3.2 Ductility Levels

Structural systems covered by the Code may be designed to possess different ‘ductility’ levels according to the following classification:

1. **Ductility Level I (DL I)** - is that proper to structures proportioned in accordance to BS 8110 (1985) with additional requirements on detailing contained in 17.10.8.
   
   This ductility level, I is suitable for low rise buildings.

2. **Ductility Level II (DL II)** - for this level seismic provisions are to be adopted, enabling the structure to enter the inelastic range of response under repeated reversed loading, while avoiding premature brittle-type failures.

3. **Ductility Level III (DL III)** - special procedures for the evaluation of design action and for the proportioning and detailing of the elements are to be adopted to ensure the development of selected stable mechanisms associated with large energy dissipation capacities. DL III structures should be preferred whenever large uncertainties exist (e.g. Local amplification effects of difficult evaluation etc)

### 17.10.4 METHODS OF ASSESSMENT

#### 17.10.4.1 Basic data

**17.10.4.1.1 Material Characteristics**  

<table>
<thead>
<tr>
<th>Ductility Level</th>
<th>Minimum Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL I</td>
<td>C20</td>
</tr>
<tr>
<td>DL II</td>
<td>C20</td>
</tr>
</tbody>
</table>

**17.10.4.1.2 Material Safety Factor,**

Design values of strength for concrete and steel shall be obtained from their respective characteristic values by using the factors:

- **Concrete**  
  \[ \gamma_c = 1.5 \]

- **Steel**  
  \[ \gamma_s = 1.15 \]

**17.10.4.1.3 Structure Behaviour Factors**

(1) The values of the behaviour factor K, defining the intensity of the design action (clause
17.10.5.3) as a function of the structural type and of the selected ductility level, are given in Table 17.10.4.2

Table 17.10.4.2 DESIGN BEHAVIOUR FACTORS

<table>
<thead>
<tr>
<th>Structural System</th>
<th>Ductility Level I</th>
<th>Ductility Level II</th>
<th>Ductility Level III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>2</td>
<td>3.5</td>
<td>5</td>
</tr>
<tr>
<td>Wall and Dual</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

(2) The values of K in Table 17.10.4.2 for wall and dual structures apply if, at least 50% of the lateral force in both directions is resisted by coupled walls.

(3) If condition 17.10.4.1.3(2) is not satisfied, the K values for wall and dual structures shall be reduced by a factor of 0.7.

(4) Ductility Level I is permitted only for Class II structures in areas of moderate seismicity.

(5) Class I structures to be built in high seismicity areas shall be preferably designed for ductility level III. If appropriate, K values relative to DL II could be used in this case.

17.10.4.2 Structural analysis

17.10.4.2.1 Building Configuration

A building shall be classified as regular when the following conditions are satisfied, regarding both plan and vertical configuration.

(a) Plan Configuration

(i) The building has an approximately symmetrical plan configuration with respect to, at least two orthogonal directions along which the earthquake resisting elements are oriented. When re-entrant corners are present, they do not exceed 25 percent of the building external dimension.

(ii) At any storey the distance (measured in the direction orthogonal to that of the seismic action) between the centre of mass and that of the stiffness does not exceed 15% of the ‘resistance radius’ defined as the square root of the ratio of storey torsional and translation stiffnesses.

(b) Vertical Configuration

(i) The stiffness and mass properties are approximately uniform along the building height.

(ii) In frame structures, the ratio between actual shear capacity (sum of shear forces contributed...
by all vertical elements at their design strengths) and design shear does not differ more than 20 percent, for any two storeys of the building.

(iii) In the case of a gradual setback along its height, the setback at any floor is not greater than 10% of the plan dimension in the direction of the setback. This clause need not be complied with if the setback occurs within the lower 15% of the total height of the building.

17.10.4.2.2 Application of Seismic Action

(1) Horizontal Action

(i) The seismic actions shall be applied to the building in the directions producing in each element the most unfavourable effect.

(ii) In buildings having one axis of symmetry, the seismic action can be assumed as acting separately along this axis and its orthogonal direction

(2) Vertical Action

\[ C_d = \frac{1}{A \cdot S \cdot \alpha} \cdot \frac{1}{K} \]

(i) The vertical component of the seismic action shall be considered in the design of non-vertical cantilevers and of prestressed beams.

17.10.4.2.3 Analytical Model

(1) The determination of the seismic effects on the structure shall be based on an idealized mathematical model which is adequate for representing the actual behaviours; the model shall also account for all non-structural elements that can influence the response of the main resisting system.

(2) For the purpose of the present Code, the determination of the load effects due to design forces may be based on a linear elastic model of the structural system.

(3) Regular buildings can be designed according to the simplified method of analysis (indicated as equivalent static analysis) described in 17.10.4.2.4 provided their height does not exceed 80m, and the fundamental period is shorter than 2 secs.

(4) If conditions in 17.10.4.2.3.(3) are not satisfied or if the building is of irregular type, the dynamic method in 17.10.4.2.5 shall be applied.

17.10.4.2.4 Equivalent Static Analysis

(1) Horizontal Design Forces

(a) The design lateral force to be applied at each floor level in the direction being analysed, shall be given by:

\[ F = C_d \cdot \gamma_i \cdot W_i \]

where \( C_d \) = design seismic co-efficient, equal in value to the design response spectrum, as given in Clause 17.10.5.3.4

\( \gamma_i \) = distribution factor, depending on the height of the floor, measured from the building base

\( W_i \) = total gravity load at floor \( i \)

(b) In cases where the period \( T \) is not calculated from methods of mechanics \( C_d \) shall be taken as:

\[ \gamma_i \]

(3) The distribution factor \( \gamma_i \) is given by the following expression

\[ \gamma_i = \frac{i}{\sum \gamma_i \cdot W_i / h_i} \]

(4) where \( h_i \) is the height of floor \( i \) from the foundation level.

(2) Torsional Effects

(a) At each floor of the building, the lateral design force shall be assumed to be displaced from its nominal location at the distances \( e_1 \) and \( e_2 \) illustrated in Figure 5.10.4.1, whichever is most unfavourable for every member to be checked.
Fig. 5.10.4.1 - Torsional Effects

(b) The expressions for $e_1$ and $e_2$ are:

$$e_1 = 0.5d + 0.05a$$
$$e_2 = 0.05a$$

(c) The total shear force and torsional moment at the generic floor shall be distributed to the various resisting elements below that floor with due consideration of their relative stiffness as well as of the stiffness of the diaphragm.

(d) Symmetrical Cases: When complete symmetry of stiffness and mass about one axis parallel to the direction of the seismic excitation exists, torsion effects can be accounted for by means of the following simplified procedure:

(i) the lateral design force shall be applied at the floor centre of gravity, to be distributed to the various elements as above;

(ii) the actions in each of the elements shall be further multiplied by a factor $\xi$ defined as:

$$\xi = 1 + 0.6 \frac{x}{a}$$

where $x$ is the distance of the element from the floor centre of gravity, measured perpendicularly to the direction of seismic action.

(3) Second Order Effects

(a) Second-order effects on storey shears and moments need not be considered when the following condition is satisfied at every floor:

$$\Delta_{el} = \frac{V}{K} = \frac{\text{elastic interstorey drift due to design action}}{\text{behaviour factor}}$$

$$h = \text{floor height}$$

$$W = \text{total gravity load above the considered storey}$$

(b) The deformability index $\Theta$ shall not in any case exceed the value 0.20;

(c) For $0.10 < \Theta < 0.20$ second order effects shall be accounted for by means of one of the statistical methods indicated in BS 8110 (1985).

5.10.4.2.5 Modal Analysis Procedure

(1) Modelling

(a) If the building can vibrate in two orthogonal directions without significant coupling, it can be analysed by means of two separate planar models, one for each orthogonal direction

(b) The condition stated in 17.10.4.2.5(1) (a) shall be assumed to occur when 17.10.4.2.1(a) (ii) is satisfied.

(c) When 17.10.4.2.1(a)(ii) is not satisfied the model shall account for the non-planar motion of the structure.

(2) Modes

(a) In the case of planar models, the analysis shall include for each of the two orthogonal axes at least the lowest three modes of vibration, or all modes of vibration with periods greater than 0.4 secs., whichever is greater.
(b) For non-planar models the analysis shall include for each direction of seismic action, at least four modes, two of them predominantly translational and two predominantly rotational, or all modes of vibration with periods greater than 0.4 secs., whichever is greater.

(c) The mode considered shall be those with the greatest participation coefficients for the direction under consideration.

(3) Combination of Modal Responses

The response quantities (force, displacements etc) separately obtained for each mode under the effect of the design response spectrum given in Clause 17.10.5.3.4 shall be combined to obtain their corresponding design values by taking the square root of the sum of the squares of modal values.

(4) Torsional Effects

(a) At each floor of the building the mass contributing to inertia forces shall be assumed to be displaced from its nominal location by the amount "0.05a" whichever is more unfavourable for the element to be checked, ‘a’ being the dimension of the building in the direction orthogonal to that of the considered seismic action.

(b) When the building is analysed by means of planar models (Clause 17.10.4.2.5 (1)), torsional effects can be accounted for by increasing the action effects due to the translational oscillations of the building by the factor $\xi$ defined as:

$$\xi = 1 + 0.6 \frac{x}{a}$$

where $x$ is the distance of the planar element considered from the floor centre of gravity, measured perpendicular to the direction of the seismic action.

(5) Second - order effects

Clause 17.10.4.2.4 (3) apply.

17.10.5.1 Seismic Zones

For the application of this Code, a seismic risk map (Fig 17.10.5.1) has been used to discretize the area of Ghana into a number of zones. Within each zone the normalized ground acceleration is assigned a constant value as shown in Table 17.10.5.1.
17.10.5.2 Characteristics of Seismic Actions

(1) For the purpose of the Code, the ground motion shall be adequately described by means of:

(a) the peak ground acceleration $A_{\text{max}}$, treated as a random variable of known distribution;

(b) one or more response spectra for horizontal motion, having a form appropriate for the area and firm soil conditions, normalized to $A_{\text{max}} = 1$ and probabilistically characterized;

(c) one or more response spectra for vertical motion, scaled to $2/3$ of the correspondence horizontal motion response spectra.

d) The regional values in table 17.10.5.1 should serve as a guide only. The particular PGA value for a specific site should be determined from the regional values based on the geotechnical characterization of the site to recommend a specific PGA value considering sites proximity to fault line, subsoil densification (using, for example, standard penetration test values - SPT) and soil classification, groundwater conditions and the functions of the building etc.

(2) For particular zones, for instance, where geological evidence indicates the possibility of ‘near field’ type of shocks (for which the response spectrum concept is inadequate) or where there is extensive and deep soil layering (for which selective amplification can occur) the expected characteristics of ground motion shall be determined by special studies.

17.10.5.3 Design Seismic Action

17.10.5.3.1 Normalized Elastic Response Spectrum

For the purpose of this Code, the shape of the ‘standard’ (rocky or firm soil condition) elastic response spectrum normalized to a unit peak ground acceleration shall be idealized as shown in Fig. 1.4.2.

![Fig. 17.10.5.2 - Normalised Elastic Response Spectrum](image)

17.10.5.3.2 Site Effects

When more detailed knowledge of the effects of local soil conditions and on the characteristics of ground motions arriving at the site from possibly different sources is not available the procedure in Clause 17.10.5.3.2 (1) and (2), and 17.10.4.4.3 shall be applied.

(1) Soil Profile Types

The effects of site conditions on building response shall be established based on the soil profile types defined as follows:

i SOIL PROFILE S1:

Rock of any characteristic either shale-like or crystalline (such material may be characterized by a shear wave velocity greater than 800mm/sec); or stiff soil conditions where the soil depth is less than 60m and the soil type overlying rock are stable deposits of sands gravel or stiffer clays.

ii SOIL PROFILE S2:

Deep cohesionless or stiff clay soil conditions, including sites where the soil depth exceeds 60m and the soil types overlying rock are stable deposits of sands, gravels or stiff clay.

iii SOIL PROFILE S3:

Soft-to-medium stiff clays and sands, characterized by 10m or more of soft-medium stiff clay with or without intervening layers of sand and other cohesionless soils.
In locations where soil properties are not known in sufficient detail to determine the soil profile type or where the profile does not fit any of the three types, soil profile S2 shall be used.

(2) Site Co-efficient

The site co-efficient S is used to modify the standard elastic response spectrum to account for the site condition. Its values are given in Table 17.10.5.2

<table>
<thead>
<tr>
<th>Soil Coefficient</th>
<th>Soil Profile Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>S1</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 17.10.5.2: SITE COEFFICIENT

17.10.5.3.3 Site - Dependant Normalized Elastic Response Spectrum

The site-dependent normalized elastic spectra for the three soil profiles are shown in Fig 5.10.5.3, their ordinates being defined as the smallest from the following expressions:

\[
R a(T) = \frac{I}{K} \cdot \alpha \cdot (T/T_1)^eta
\]

for soil type S1, S2 and S3, or

\[
R a(T) = 0.8 \cdot I \cdot A \cdot \alpha \cdot (T/T_1)^eta
\]

for soil type S3 if \( A \geq 0.3g \)

\[
R a(T) = I \cdot A \cdot \alpha \cdot S \cdot (T_2/T)^{\beta} \cdot \frac{I}{K}
\]

Where:

- \( I \) is the importance factor defined in Clause 17.10.3.1(3) (see Table 17.10.5.3)
- \( A \) is the peak ground acceleration to be adopted for the seismic zone of interest (% of g - Table 17.10.5.1)
- \( S \) is the site coefficient as given in Table 17.10.5.2
- \( K \) is the behaviour factor given in Table 17.10.4.1.3

In the case of lack of specific site-related information \( \alpha, \beta \) and \( T_2 \) are assigned the following values:

\( T_1 = 0.12 \) secs \( T_2 = 0.4 \) secs

\( \alpha = 2.5 \)

\( \beta = 2/3 \)

However, for soil type S3 the value \( T_1 = 0.25 \) secs. can be adopted.

Spectra for vertical motions may be determined with sufficient accuracy by multiplying the ordinates of the spectra for horizontal motions by a factor of 2/3.
\[ \alpha = 2.5, \quad \beta = \frac{2}{3}, \quad T_2 = 0.4 \text{ secs.} \]

### Table 17.10.5.3: IMPORTANCE FACTOR

<table>
<thead>
<tr>
<th>Class</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.4</td>
</tr>
<tr>
<td>II</td>
<td>1.0</td>
</tr>
</tbody>
</table>

#### 17.10.6 DESIGN ACTIONS

##### 17.10.6.1 General

Structural elements shall be dimensioned and verified (see clause 17.10.7) for design actions as defined in this clause.

##### 17.10.6.2 Ductility Level I: DL I

DL I structures shall be dimensioned directly on the basis of the results of structural analysis, with a possible redistribution of action effects in accordance with BS.8110 (1985)

##### 17.10.6.3 Ductility Level II: DL II

1. Elements subject to bending

\[ N_d \leq 0.1 \cdot A_s \cdot f_{cd} \]

(a) Bending moments:

The design bending moments shall be those obtained from linear analysis of the structure for the load combination given by equation 17.10.4.1.1. Redistribution according to BS.8110 (1985) is permitted.

(b) Shear Forces:

(i) The design shear forces shall be determined from the condition of static equilibrium of the element subjected to the relevant transverse load, if any, and a rational combination of the end moments.

(ii) The end moments shall correspond to the design flexural strengths of the end actions based on actual reinforcement provided.

(iii) The algebraic ratio between the maximum and minimum values of shear at each end clause shall be denoted by \( \zeta \). The value of \( \zeta \) should not be taken less than minus one (Fig. 5.10.6.1).

Fig 5.10.6.1 - DESIGN SHEAR FORCES

(2) Elements Subject to bending and axial force

\[ N_d > 0.1 \cdot A_s \cdot f_{cd} \]

(a) Axial forces and bending moments

(i) For regular structures, three storeys and higher, to which equivalent static analysis has been applied, the column moment due to lateral forces alone shall be multiplied by the dynamic amplification factor \( w \) as given by the following expressions:

**Planar Frames**

\[ w = 0.6 \cdot T_1 + 0.85 \quad (1.3 \leq w \leq 1.8) \]

17.10.6.1

**Spatial Frames**

\[ w = 0.5 \cdot T_1 + 1.10 \quad (1.5 \leq w \leq 1.9) \]

17.10.6.2

where \( T_1 \) is the fundamental period of the structure.

(ii) The values of the dynamic factor \( w \) given in 17.10.6.3(2)(a)(i) are applicable to storeys within the upper two-thirds of the building height. Below this level a linear variation of \( w \) should be assumed: the value at first floor level should be taken as 1.3 and 1.5 for planar and spatial frame respectively (Fig 17.10.6.2).
Fig. 17.10.6.2 - Values of Dynamic Factor at Various Floors

(iii) Column moments in addition shall satisfy the condition on the relative strength between columns and beams framing into a joint as specified in Clause 17.10.7.1(3).

(b) Shear Forces

(i) In evaluating the design shear forces from the condition of static equilibrium the design end moments shall be those producing maximum shear force obtained from analysis, modified if appropriate by the dynamic magnification factor.

(3) Structural Walls

(a) The design actions shall be those obtained from a linear analysis of the building modified as appropriate in accordance with Clauses 17.10.6.3(1)(b) to 17.10.6.3(3)(c).

(b) Redistribution

(i) The distribution of the total force to the various walls, as obtained from the elastic analysis may be modified provided the global equilibrium is maintained and the maximum value of the action in any wall is not reduced by more than 30%

(ii) In a coupled wall, the elastic shear force in the coupling beams can also be modified with a maximum reduction of 20% provided that corresponding increases in the shear capacities of beams at other floors are made.

(c) Bending Moment Design Envelope

The design moments along the height of the wall shall be those given by a linear envelope of the calculated moment diagram, vertically displaced by a distance equal to the horizontal length of the wall. (Fig. 17.10.6.3)

Fig5.10.6.3 - BENDING MOMENT DESIGN ENVELOPE

(d) Earthquake Induced Axial Load in Coupled Walls

(i) The design axial load in the walls due to the lateral action shall be computed using the shear strengths of the coupling beams above the clause considered, calculated by using characteristic values of concrete and steel strength.

(ii) The shear strength of the beams calculated in 17.10.6.3(3)(d)(i) shall be further amplified by a factor of 1.25

(e) Dynamic Magnification Factors

(i) Where the equivalent static analysis is adopted, the shear forces in the walls shall be magnified by the dynamic amplification factor \( w \) as given by the expression below for buildings up to 5 storeys high

\[ w = 0.1N + 0.9 \ldots \ldots \ldots \quad 1.5.3 \]

where \( N \) is the number of storeys

(ii) For walls taller than five storeys, \( w \), shall be linearly increased up to the value of \( w = 1.8 \) for \( N = 15 \)
17.10.6.4 Ductility Level III: DL III

(1) Elements subject to bending
\( N_d \leq 0.1 \cdot A_e \cdot f_{cd} \)

(a) Bending moments: The design bending moments shall be those obtained from linear analysis of the structure. Redistribution according to BS 8110 (1985) is permitted.

(b) Shear Forces:

(i) The design shear forces shall be determined from the conditions of equilibrium of the element subjected to the relevant transverse loads, if any, and to a rational adverse combination of end moments, as specified in 17.10.6.4(1)(b)(iii)

(ii) The end moments shall correspond to the design flexural strengths of the end clauses based on actual reinforcement provided, multiplied by the factor

\[
w = 0.6 \cdot T_1 + 0.85 \quad (1.3 \leq w \leq 1.8)
\]

\[
\gamma_n = 1.25
\]

(iii) The algebraic ratio between the maximum and minimum values of shear force at a clause shall be denoted by \( \zeta \). For the purposes to follow, the value of \( \zeta \) should not be taken smaller than minus one. (Fig 17.10.6.4)

\[
w = 0.5 \cdot T_1 + 1.10 \quad (1.5 \leq w \leq 1.9)
\]

(2) Elements subject to bending and axial force \( (N_d > 0.1 \cdot A_e \cdot f_{cd}) \)

(a) Axial forces and bending moments

(i) The axial forces and bending moments to be used for column design shall be determined from a linear analysis of structures, eventually redistributed according to BS 8110 (1985).

(ii) For regular structures, three storeys and higher, to which equivalent static analysis has been applied, the column moment due to the lateral forces alone, shall be multiplied by the dynamic magnification factor, \( w \), as given by the following expressions:

Planar frames:

17.10.6.

Spatial frames:

17.10.6.5

where \( T_1 \) is the fundamental period of the structures.

(iii) The values of the dynamic factor, \( w \) as given in 17.10.6.4(2)(a)(ii) are applicable to storeys within the upper two-thirds of the building height. Below this level a linear variation of, \( w \), should be assumed; the value at first floor level should be taken as 1.3 and 1.5 for planar and spatial frames respectively. (Fig 17.10.6.5)
(iv) Column moments shall satisfy the condition on the relative strength between columns and beams framing into a joint (see 17.10.7.1 (3))

(b) Shear forces

(i) In evaluating the design shear forces from the conditions of static equilibrium the design end moments shall be the most adverse ones as obtained from the analysis of the structure.

(ii) The end moments as calculated above shall be further amplified, if appropriate by the dynamic magnification factors, and by the $\gamma_n$ factor: $\gamma_n = 1.10$

(3) Beam - Column Joints

(a) The design actions shall be those induced in the joint when the design ultimate moments of the beam or beams multiplied by a factor $\gamma_n$, equal to 1.25 are developed, except in cases when hinges are permitted to form in the columns (see Clause 17.10.7.1 (3)) The axial force in the column shall be the minimum corresponding to the design seismic actions.

(b) Horizontal Shear Force ($V_{jh}$)

(i) Interior Joint (see Fig. 17.10.6.6)

The shear force $V_{jh}$ across a typical interior joint without prestressing may be calculated from:

$$V_{jh} = \gamma_n \left( A_{s1} + A_{s2} \right) f_{yd} \cdot V_{col}$$

17.10.6.6

where

$$V_{col} = 2 \left( \frac{l_1}{l_{1n}} \cdot M_1 \right) / \left( l_c + l'_c \right)$$

$$V_{col} = 2 \left( \frac{l_1}{l_{1n}} M_1 + \frac{l_2}{l_{2n}} M_2 \right) / \left( l_c + l'_c \right)$$

17.10.6.7

$$\begin{vmatrix}
  l_{1n} & l_{2n}
\end{vmatrix}$$

$$V_{jh} = V_{jh} \cdot \frac{b_b}{h_c}$$

17.10.6.8

(c) Vertical Shear Force ($V_{jv}$)

The vertical shear force may be approximately as follows:
17.10.6.9

where

\[ b_b = \text{depth of beam} \]
\[ h_c = \text{width of column} \]

(d) When two non co-planar frames have common joints, verification of these joints may be considered in each direction separately.

(4) Structural Walls

(a) The design actions shall be those obtained from a linear analysis of the building modified as appropriate in accordance with clause 17.10.6.4(b) - (f)

(b) Redistribution

(i) The distribution of the total force to the various walls, as obtained from the elastic analysis, may be subsequently modified, provided the global equilibrium is maintained and the maximum value of the action in any wall is not reduced by more than 30%

(ii) In a coupled wall, the elastic shear forces in the coupling beams can also be modified with a maximum reduction of 20% provided corresponding increases in the shear capacities of beams at other floors are made

(c) Bending Moment Design Envelope

The design moments along the height of the wall shall be those given by a linear envelope of the calculated moment diagram, vertically displaced by a distance equal to the horizontal length of the wall. (Fig17.10.6.7)

\[ w = 0.1 \, N + 0.9 \]

17.10.6.10

where \( N \) is the number of storeys.

For walls taller than 5 storeys \( w \) shall be linearly increased up to the value of

\[ w = 1.8 \text{ for } N = 15 \]
(f) **Shear Forces**

(i) The design shear forces in walls shall be compatible with the actual flexural strength that can possibly be developed at the base of the walls.

\[ \gamma_n = \frac{M_{ud}^+}{M_d} \]

17.10.6.11

Where:

- \( M_d \) is the design moment obtained from the analysis, and
- \( M_{ud}^+ \) is the flexural strength of the clause on the basis of actual reinforcement provided calculated by using the characteristic values of concrete and steel strengths.

In evaluating the flexural strength of the base clause the appropriate axial load shall also be considered.

(ii) The design shear forces shall be obtained by multiplying the shear forces due to the Code loading by the following \( \gamma_n \) factor,

\[ \gamma_n = \frac{M_{ud}^+}{M_d} \]

(iii) The factor \( \gamma_n \) need not be taken greater than 4

---

17.10.7 DIMENSIONING AND VERIFICATION

17.10.7.1 Linear Elements (General)

(1) **Design Strengths**

The design strengths of the structural elements in bending, bending with axial force, shear and torsion shall be evaluated in accordance with BS 8110 except as modified by this Clause 17.10.7.

(2) **Limiting Axial Load**

The design axial compression load under the most severe load combination including seismic action shall not exceed the following limit.

(3) **Beam - Column Strength Ratio**

(a) Except for cases where hinge formation in column is permitted (see 17.10.7.1 (3) (b) (iii) at any beam - column joint the sum of the absolute values of the design ultimate moments of the columns (under the most unfavourable value of the axial force) shall not be less than the sum of the absolute values of the design ultimate moments of the beams framing into the joint (Fig.17.10.7.1)

(b) **DL III Structure**

(i) For columns of DL III Structures, the design bending moments shall account for possible increase in strength of the beams framing into the joint.

(ii) Unless otherwise justified, the global strength increase can be assumed as:

\[ \gamma_n = 1.15 \] 17.10.7.1

and is applicable to all storeys, including column bases in the first storey.
(iii) Development of plastic hinges in columns and of columns hinge mechanism (i.e. exemption from the prescription on beam-column ratio) is permitted in the following cases:-

- for frames having four or more columns, hinging is permitted to occur in one column for every three others remaining elastic.

- column hinge mechanisms are permitted in single and two-storey buildings and in the top storey of multi-storey building.

(4) Resistance to Shear

(a) Contribution of Concrete

The magnitude of the term $V_{cd}$, expressing design resistance contributed by concrete shall be taken as follows:

(i) When $N_d \leq 0.1 A_g f_{cd}$, $V_{cd}$ shall be assumed to be zero in all regions where stirrup-ties are required in accordance with Clause 5.10.8.2.3 (with the exception of Case (c))

(ii) When $N_d > 0.1 A_g f_{cd}$, $V_{cd}$ shall be computed by the expression

$$V_{cd} = 2\tau_{Rd} b_w d \beta_1$$

where the values of $\tau_{Rd}$ are given in Table 1.6.1 as functions of concrete grades and $\beta_1$ is given by 17.10.7.4

$$\beta_1 = 1 + \frac{M_o}{M_d} \leq 2$$

$$17.10.7.3$$

where $M_o$ and $M_d$ are decompression moment and design moment respectively. $M_o$ shall be computed by the expression

$$M_o = N_d h/2$$

$$17.10.7.4$$

Table 17.10.7.1: DESIGN CONCRETE SHEAR STRESS

<table>
<thead>
<tr>
<th>Concrete grade</th>
<th>$\tau_{Rd}$ (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.30</td>
</tr>
<tr>
<td>30</td>
<td>0.34</td>
</tr>
<tr>
<td>35</td>
<td>0.38</td>
</tr>
</tbody>
</table>

(b) Transverse Reinforcement

(i) $N_d \leq 0.1 A_g f_{cd}$

(ii) $\zeta \geq 0$.

The resistance to shear provided by the reinforcement: $V_{wd}$ shall be given by

$$V_{wd} = 0.87 h A_{sw} \cdot f_{yk} s \cdot \gamma_s$$

where,

- $h$ is the effective depth,
- $A_{sw}$ the individual cross-clauseal area of a mat of transverse reinforcement, and
- $s$ the spacing of the mats of transverse reinforcement measured parallel to the axis of the beam.

(ii) $\zeta < 0$. For $V_{sd}$ not exceeding the limit value $V_{Rd1}$ where

$$V_{Rd1} = 3(2 + \zeta) \tau_{Rd} b_w d$$

$$17.10.7.6$$

same requirement as in (i) above applies.

For $V_{sd}$ exceeding the limit value $V_{Rd2}$ where

$$V_{Rd2} = 6(2 + \zeta) \tau_{Rd} b_w$$

$$17.10.7.7$$

the entire shear shall be resisted by diagonal reinforcement across the web, that is, steel bars inclined in two directions shall equilibrate with their compression and tension components the
shear forces of opposite sign \( V_{sd} \) and \( \zeta V_{sd} \) occurring at the clause.

- For \( V_{Rd1} < V_{sd} < V_{Rd2} \)

one half of the maximum shear force shall be carried by doubly diagonal bars, the other half by transverse reinforcement.

(ii) \( N_d > 0.1 A_g f_{cd} \)

The resistance to shear shall be checked as for Case (I) (i)

17.10.7.2 Beam - Column Joints (DL III only)

(1) Horizontal Joint Shear

(a) Nominal Horizontal Shear Stress

(i) The nominal horizontal shear stress in the joint as given by the following expression

\[
\tau_{jh} = \frac{V_{jh}}{b_j h_c} \quad \text{......17.10.7.8}
\]

shall not exceed the value \( 20 \tau_{Rd} \)

(ii) The effective joint width \( b_j \) shall be taken as:

- when \( b_c > b_w \)

\[
\{ \begin{array}{l}
V_{ch} = (2 \tau_{Rd} \sqrt{(\sigma_{cm} - 0.1 f_{ck})} )b_j h_c \quad \text{17.10.10} \\
\text{or} \quad b_j = b_w + 0.5 h_c \\
\text{whichever is smaller} \quad \text{(Fig. 5.10.7.2)}
\end{array} \}
\]

- when \( b_c < b_w \)

\[
\{ \begin{array}{l}
\text{either} \quad b_j = b_w \\
\text{or} \quad b_j = b_c + 0.5 h_c \quad \text{17.10.10} \\
\text{whichever is smaller}
\end{array} \}
\]

17.10.7.11

(ii) When beams are prestressed through the joint:

\[
V_{ch} = 0.7 P_{cs} \quad \text{17.10.7.12}
\]

where \( P_{cs} \) is the permanent force in the prestressing steel that is located within the central third of the beam depth.

(iii) When the design precludes the formation of any beam plastic hinge at the joint, or when all beams at the joint are detailed so that the critical
clause of the plastic hinge is located at a distance from the column face not less than \( h_b \), or for external joints where flexural steel is anchored outside the column core in a beam stub.

\[
V_{ch} = A'_{s} \cdot V_{jh} \cdot \frac{1 + N_d}{17.10.7.13 - A_s \cdot 2 \cdot 0.4A_yf_{ck}}
\]

where the ratio \( A'_{s}/A_s \) of the compression to the tension longitudinal beam reinforcement shall not be taken larger than 1.0. When the axial column load results in tensile stresses over the gross concrete area exceeding 0.2 \( f_{ck} \) the entire joint shear shall be resisted by reinforcement.

For axial tension smaller than this limit, the value of \( V_{ch} \) may be linearly interpolated between zero and the value given by equation 5.10.7.13 with \( N_d \) taken as zero.

(iv) When parts \( A_{a1} \) and \( A_{a2} \) of the column tensile reinforcement and \( A_{s1} \) and \( A_{s2} \) of the adjacent beams are bent vertically and anchored in the tensile face of the column

\[
V_{ch} = A_s \cdot \frac{f_{vk}}{\gamma_s} \quad 17.10.7.14
\]

where \( A_s \) is the smaller of \( A_{a1} \) and \( A_{a2} \).

The values of \( V_{ch} \) obtained from equations (5.10.7.11, 5.10.7.12, 5.10.7.14) may be added where applicable. (See Fig 5.10.7.3)

---

**Fig. 17.10.7.3 - Shear Force carried by Concrete**

(c) **Horizontal Shear Reinforcement**

(i) The horizontal shear reinforcement shall be capable of carrying the design joint shear force:

\[
V_{sh} = V_{jh} - V_{ch} \quad 17.10.7.15
\]

across a corner-to-corner potential failure plane. The effective total area of the horizontal reinforcement that crosses the critical diagonal plane and is situated within the effective joint width \( b_j \) shall not be less than:

\[
A_{jh} = \frac{V_{sh}}{f_{vk} / \gamma_s} \quad 17.10.7.16
\]

(ii) Horizontal sets of stirrup ties shall be distributed as uniformly as practicable between layers of the top and bottom beam reinforcement.

(2) **Vertical Joint Shear**

(a) The vertical shear reinforcement shall be able to resist a vertical shear force

\[
V_{sv} = V_{jv} - V_{cv} \quad 17.10.7.18
\]

where the value \( V_{cv} \) shall be determined from

\[
V_{cv} = A'_{sc} \left( V_f \cdot 0.6 + \frac{N_d}{A_{sc} A_yf_{ck}} \right) \quad 17.10.7.18
\]
where $A'_{sc}$ and $A_{sc}$ are the areas of longitudinal compression and tension reinforcement in columns respectively, with the following exceptions:

(i) Where axial load results in tensile stress over the column clause, the value of $V_{cv}$ shall be linearly interpolated between the value of $V_{cv}$ given by equation (5.10.7.18) with $N_d$ taken as zero when the axial tension over the gross concrete area is $0.2 f_{ck}$;

(ii) Where plastic hinges are expected to form in the column above or below a joint, part of the primary seismic energy dissipating mechanism, $V_{cv}$ shall be assumed to be zero for any value of the axial load on the column.

(b) The required area of vertical joint shear reinforcement within the effective joint width $b_j$ shall be determined from:

$$A_{jv} = \frac{V_{sv}}{\gamma_s} \quad \ldots \ldots \quad 17.10.7.19$$

10.10.7.3 Structural Walls

(1) General

The design strengths of walls and coupling beams shall be evaluated as for linear elements (Clause 17.10.7.1) except as modified by provisions in clause 1.6.3

(2) Resistance to Shear

(a) Maximum Allowable Shear Stress

The maximum nominal design shear stress in a wall clause, evaluated by means of the expression

$$\tau_d = \frac{V_d}{A_g} \quad \ldots \ldots \quad 17.10.7.21$$

where $V_d$ is the design force computed in accordance with Clauses 5.10.6.3 (3) or 5.10.6.4 (4) shall not exceed the following limit

$$\tau_d \leq 10 \tau \quad \ldots \ldots \quad 17.10.7.22$$

(b) Contribution of Concrete to Shear Strength

(i) In the potential plastic zone, as defined in Clause 5.10.8.5.3(2), the contribution of concrete to shear resistance is assumed to be zero, unless the minimum axial load produces an average compression stress over the gross concrete area of the wall equal at least to:

$$0.1 f_{cd} \quad \ldots \ldots \quad 17.10.7.23$$

In which case the shear contributed by concrete shall be computed by:

$$\tau_{cd} = 2.5 \tau_{Rd} \cdot \beta_1 \quad \ldots \ldots \quad 17.10.7.24$$

(ii) Outside the potential hinge zone, and when the average compressive stress is less than $0.1 f_{cd}$, the shear stress contributed by concrete shall be taken as:

$$\tau_{cd} = 2 \tau_{Rd} \quad \ldots \ldots \quad 17.10.7.25$$

while in case the average stress is greater than $0.1 f_{cd}$ the value is taken as:

$$\tau_{cd} = 2.5 \tau_{Rd} \cdot \beta_1 \quad \ldots \ldots \quad 17.10.7.26$$
(c) **Web Reinforcement**

Horizontal bars fully anchored at the extremities of the wall clause, shall be provided in the amount

$$\rho_v = \frac{A_v}{b.s_v} = \tau_d - \tau_{cd} \quad \text{..............} 17.10.7.27$$

$$\text{b.s}_v \quad f_{yd}$$

while the vertical reinforcement ratio shall be:

$$\rho_v = \frac{A_v}{b.s_h} = \frac{\tau_d - \tau_{cd} - N_d / A_y}{f_{yd}} \quad \text{..............} 17.10.7.28$$

The vertical shear reinforcement can be assumed to fully contribute to the required flexural strength.

(3) **Coupling Beams**

(a) Symmetrical flexural reinforcement, ($\rho = \rho'$), shall be adopted in case of usual arrangement.

(b) Design for flexure and shear shall be carried out as for ordinary beams unless the following limits are exceeded

$$\rho = \frac{l\sqrt{(8f_{ck})}}{(4.h.f_{yk})}, \quad (f_{ck}, f_{yk} \text{ in Mpa}) \quad 17.10.7.289$$

($\rho$ = longitudinal reinforcement ratio, top or bottom) in which case all flexural and shear actions shall be resisted by diagonal reinforcement in both directions.

17.10.7.4 Verifications

(1) **Collapse Verification**

$$\frac{0.010}{K}, \quad K$$

(a) For the purpose of the present Code, a structure shall be deemed to satisfy the safety requirement against collapse if the following conditions are met

(i) the strength and stability verifications are satisfied;

(ii) the elements are dimensioned and detailed in accordance with rules given in Clauses 17.10.7 and 17.10.8 relative to the appropriate structural type and intended ductility level.

(2) **Strength Verification**

The following condition must be satisfied for every element:

$$S_d \leq R_d \quad \text{..............} 17.10.7.30$$

where $S_d$ is the design load effect on the element considered, evaluated according to Clause 17.10.6.

$$R_d$$ is the design strength of the same element, evaluated according to Clause 17.10.7

(3) **Stability Verification**

The stability verification shall be considered satisfied if:

(i) the deformability index $\Theta$ formula 5.10.4.2.7 is less than 0.1,

(ii) for $0.1 < \Theta < 0.2$, the second order effects are calculated and added to the design forces.

(iii) the stability verification cannot be satisfied if $\Theta > 0.20$.

(4) **Serviceability Verification**

(a) The elastic drift, $\Delta_{el}$ resulting from the application of the horizontal forces specified in 5.10.4.2.4 or from the dynamic procedure in 5.10.4.2.5, shall at any storey satisfy the condition:

$$\Delta_{el} \leq \frac{0.010}{K}, \quad h \quad 17.10.7.31$$

where $h$ is the clear height of the floor.

(b) For Class II buildings, the indicated limits may be increased by 50% if it can be demonstrated that the finishes adopted are not brittle-type and can accommodate without significant damage to those limits.
(c) When the limits in (a) and (b) are exceeded, separation of the non-structural elements is required, of an amount adequate for permitting an inter storey drift equal at least to:

\[ \Delta = 0.35 \Delta_{el} \cdot K \quad \ldots \quad 17.10.7.32 \]

to take place without restraint.

(d) In no case shall inter-storey drift \( \Delta_{el} \) exceed the limit:

\[ \Delta_{\text{max}} = \frac{0.025}{K} \cdot h \quad \ldots \quad 17.10.7.33 \]

(5) Maximum Expected Displacements

The maximum expected displacements of the building shall be obtained by multiplying the displacements produced by the system of horizontal forces specified in 17.10.4.2.4 or those obtained from dynamic analysis as in 17.10.4.2.5 by the appropriate values of the behaviour factor \( K \).

17.10.8 DETAILING, EXECUTION, USE

17.10.8.1 General

When no explicit distinction is made, the provisions in this clause apply to both DL II and DL III structures. Provisions applicable to DL I structures are always explicitly stated.

17.10.8.2 Elements Subject to Bending

\[ N_{d} \leq 0.1 \cdot A_{g} \cdot f_{cd} \]

17.10.8.2.1 Geometrical Constraints

DL II and DL III Structures

Unless special proofs for exemption are given, the following dimensional limitations shall be satisfied:

(i) The width shall not be less than 200mm or more than the width of the supporting column, plus lengths, on each side of this member not exceeding one fourth of the depth of the column cross clause.

(ii) The ratio b/h shall not be less than 0.25

(iii) The ratio l/h shall not be less than 4 (This requirement does not apply to coupling beams in wall structures, Clause 5.10.7.3(3).(Fig 17.10.8.1)

(iv) The eccentricity of any beam relative to the columns into which if frames as measured by the distance between geometrical centre lines of the two members shall not exceed \( 1/4 \cdot b_{c} \) (Fig 17.10.8.2)

(a) Maximum eccentricity of beams

(b) Example of bad structural layout for this and analogous cases, if they cannot be avoided, special detailing shall be provided to ensure continuity with ductile behaviour.
17.10.8.2.2 Longitudinal Reinforcement

(1) DL II and DL III Structures

(a) At any clause of the member the tensile reinforcement ratio for top or the bottom reinforcement shall not be less than:

\[ \rho_{\text{min}} = \frac{1.4}{f_{yk}} \left( f_{yk} \text{ in Mpa} \right) \]

nor greater than

\[ \rho_{\text{max}} = \frac{7}{f_{yk}} \]

with \( \rho_{\text{min}} \) and \( \rho_{\text{max}} \) referred to the gross concrete area, \( A_g \).

(b) At least two 12mm bars shall be provided both top and bottom throughout the length of the members.

(c) Within any potential plastic hinge region, the compression reinforcement ratio \( \rho' \) shall not be less than one half of the tension reinforcement ratio at the same clause.

(d) At least one quarter of the larger of the top reinforcement required at either end of the member shall be continued throughout its length.

(e) In T and L beams built integrally with slabs, the effective reinforcement to be considered near column faces in addition to all longitudinal bars placed within the web width of beam, shall be as follows:

(i) At interior columns when a transverse beam of similar dimensions frames into column, all reinforcement within that part of the slab which extends a distance 4 times the slab thickness from each side of the column. (Fig 17.10.8.3a)

(ii) At interior columns where no transverse beam exists all reinforcement within that part of the slab which extends a distance of 2.5 times the thickness of the slab from each side of the column. (Fig 17.10.8.3b)

(iii) At exterior columns where a transverse beam of similar dimensions frames into column and where the beam reinforcement is to be anchored all reinforcement within that part of the slab which extends a distance of twice the slab thickness from each side of the column. (Fig 17.10.8.3c)

(iv) At exterior columns where no transverse beam exists, all reinforcement within the width of the column. (Fig. 17.10.8.3d)

Fig. 17.10.8.3 - Areas of Effective Reinforcement

(v) In all cases, at least 75% of the reinforcement in each face providing the required flexural capacity, must pass through or be anchored in the column core.

(2) DL I Structures

Clause 17.10.8.2.2. (1) (a) only needs to be satisfied.

17.10.8.2.3 Minimum Transverse Reinforcement

(1) Transverse reinforcement as specified in this clause shall be provided unless a larger amount is required to resist shear (clause 17.10.7.1.(4) ). Portions of the beams to be considered as ‘critical’ regions are:
(a) Twice the member depth, measured from the face of the supporting column, or beam, towards midspan at both ends of the beam.

(b) Twice the member depth on both sides of a clause where yielding may occur.

(c) Wherever compression reinforcement is required.

(2) DL II Structures

In the critical regions as defined in 17.10.8.2.3 (1), stirrup ties of not less than 6mm diameter shall be provided, with maximum spacings not exceeding the smaller of:

(a) \( h/4 \)

(b) eight times the minimum diameter of the longitudinal bars

(c) 24 times the diameter of the hoop bars

(d) 200mm

The first hoop shall be located not more distant than 50mm from the face of the supporting member.

(3) DL III Structures

In the critical regions as defined in 17.10.8.2.3 (1) stirrup ties of not less than 6mm diameter shall be provided, with maximum spacing not exceeding the smaller of:

(a) \( h/4 \)

(b) six times the diameter of the longitudinal bars

(c) 150 mm

The minimum area of one leg of the transverse reinforcement shall be:

\[
A_s, \min = \frac{\sum Ab \cdot f_{yk}}{16 f_{ykt}} \cdot \frac{S}{100}
\]

17.10.8.3

\( \Sigma Ab = \) Sum of the areas of longitudinal bars at the clause considered to be restrained by the transverse leg

\( f_{yk} = \) yield strength of longitudinal bars

\( f_{ykt} = \) yield strength of stirrups

\( S = \) spacing of stirrups in mm

The first hoop shall be located not more than 50mm from the face of the supporting member. (Fig 17.10.8.4)

Fig. 17.10.8.4 Regions and Spacing of Transverse Reinforcement

17.10.8.3 Elements Subject to Bending and Axial Force \((N_d > 0.1A_g f_{cd})\)

17.10.8.3.1 General

Corner columns should be detailed according to DL III requirements.

17.10.8.3.2 Geometric Constraints

(1) DL II Structures

(a) The minimum cross-clauseal dimension shall not be less than 250mm

(b) The ratio l/b shall not exceed 25

(2) DL III Structures

(a) The minimum cross-clause shall not be less than 300mm

(b) The ratio l/b shall not exceed the value of 16 for columns having moments of opposite sign at the two extremities; 10 for cantilever columns.
17.10.8.3.3 Longitudinal Reinforcement

(1) General

(a) The reinforcement ratio shall not be less than 0.01 or larger than 0.06 including the region of lap splices.

(b) For S400 steel, the reinforcement ratio outside the splices shall not be greater than 0.045.

(c) The bars shall not be spaced further apart between centres than 200mm.

(2) DL I Structures

The provisions in 17.10.8.3.3 (1) apply to DL I Structures.

17.10.8.3.4 Transverse Reinforcement

(1) General

(a) A basic amount of reinforcement shall be provided all over the height of the column while special reinforcement shall be placed in the column critical regions defined in Clause 17.10.8.3.4 (2)

(b) The amount of reinforcement required by 17.10.8.3.4 shall be provided unless a larger amount is required to resist shear according to Clause 17.10.7.1 (4)

(2) Column Critical Regions

(a) For usual cases, critical regions are considered to be the regions at each end of a column above and below connections over a length from the faces of the connection of not less than the larger of:

(i) the longer column cross-clause dimension in the case of a rectangular cross-clause, or the diameter of the clause in case of a circular column.

(ii) one-sixth of the clear height of the column

(iii) 450mm

(b) When a masonry infill wall is in contact with one or both of the two opposite sides of the column, over the whole height or part of it, the entire column height shall be considered as a critical region. (Fig 17.10.8.5a)

(c) In case of columns with part of their height restrained due to a connection with a wall the free part of the column shall be considered as a critical region.

(3) DL II Structures

(A) Critical Regions

(a) Special transverse reinforcement having a minimum diameter of 8mm in the form of spiral or hoop reinforcement shall be provided.

(b) Cross ties to restrain longitudinal bars not directly held by hoops shall be used in accordance with BS 8110

(c) The maximum spacing between spirals or hoops shall not exceed the smaller of:

(i) eight times the minimum diameter of the longitudinal bars

(ii) one half the least cross-clauseal dimension of the clause

(iii) 200 mm

(d) The transverse reinforcement in the amount specified above shall be continued throughout the length of the beam - column joint.

(B) Non-critical regions
The minimum transverse reinforcement in non-critical regions shall be in accordance with Table 17.10.8.1

**Table 17.10.8.1:**
**TRANSVERSE REINFORCEMENT - DL II**

Critical Region $l_c = \max (h, l/6, 450 \text{ mm})$

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Critical Region $S_h = \min (8\phi_L, 1/2b, 200\text{ mm})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elsewhere $S_h = \text{mm (12}\phi_L, b, 300\text{mm)}$</td>
<td></td>
</tr>
</tbody>
</table>

*(See Fig. 17.10.8.6)*

(4) **DL III Structures**

(A) **Definition**

(a) The volumetric ratio is the ratio of volume of spiral or hoop reinforcement to total volume of concrete core (out-to-out of bars) within the spacing, $S_h$

(b) The volumetric ratio $\rho_s$ for rectangular clauses is defined as

$$\rho_s = A_{sh} / S_h \cdot h' \quad \text{17.10.8.4}$$

where $A_{sh}$ is the total area of hoop bars and supplementary cross ties in each of the principal directions of cross clause, $S_h$ is the spacing and $h'$ is the distance between centres of outer bars.

(B) **Critical Regions**

(a) The volumetric ratio of transverse reinforcement (spiral or hoops) shall not be less than the greater of

$$\rho_s = \lambda_i \cdot \frac{f_{ck}}{f_{yk}}$$

*Fig. 17.10.8.6 - Special Transverse Reinforcement. Critical Region and Spacing*
\[
\rho_s = \lambda_2 \left( \frac{A_g}{A_c} - 1 \right) \frac{f_{ck}}{f_{yk}}
\]

where, \( A_g \) = gross clauseal area

\( A_c \) = confined area of concrete and the values of \( \lambda_1 \) and \( \lambda_2 \) are given in Table 17.10.8.2 as functions of the reduced axial force ratio \( N_d / A_c f_{ck} \)

### Table 17.10.8.2: VALUES OF \( \lambda_1 \) AND \( \lambda_2 \)

<table>
<thead>
<tr>
<th>( \frac{N_d}{A_c f_{ck}} )</th>
<th>0.10</th>
<th>0.20</th>
<th>0.30</th>
<th>0.40</th>
<th>0.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \lambda_1 )</td>
<td>0.05</td>
<td>0.06</td>
<td>0.07</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>( \lambda_2 )</td>
<td>0.18</td>
<td>0.22</td>
<td>0.26</td>
<td>0.30</td>
<td>0.34</td>
</tr>
</tbody>
</table>

(b) The minimum diameter of spiral or hoops shall be 8mm.

(c) The maximum spacing between spirals or hoops shall not exceed the smaller of:

(i) six times the minimum diameter of longitudinal bars;

(ii) one fourth of the smallest lateral dimension of the clause

(d) Each longitudinal reinforcement bar or bundle of bars shall be laterally supported by the corner of a hoop having an included angle of not more than 135° or by a supplementary cross tie except that the following bars are exempted from this requirement:

(i) bars or bundles of bars which lie between two bars supported by the same hoop where the distance between the laterally supported bars or bundles of bars does not exceed 200mm between centres.

(ii) inner layers of reinforcing bars within the concrete core centred more than 75mm from the inner face of hoops.

(e) The yield force of the hoop bar or supplementary tie shall be at least one-sixteenth of the yield force of the bar or bars it is to restrain including the contribution from the bar or bars exempted under 17.10.8.3.4 (4)(B)(d)(i)

(f) Each end of a supplementary tie shall engage either a longitudinal bar or the peripheral hoop besides a longitudinal bar with a bent of at least 135° and an extension beyond the bent of at least 10 tie bar diameters. Supplementary ties and legs of hoops shall not be spaced transversely more than either 200mm or one-quarter of the column clause dimension perpendicular to the direction of the transverse steel. (Fig. 17.10.8.7).
(a) Single hoop plus two supplementary cross ties bent round longitudinal bars

(b) Single hoop plus two supplementary cross ties bent round hoop

(c) Two overlapping hoops preferred detail

(d) Two overlapping hoops not preferred detail

(e) Three overlapping hoops

(f) Four overlapping hoops

Fig. 17.10.8.7 - Typical details using overlapping hoops

(C) Non-critical regions

The requirements relative to the critical regions of DL II columns apply (see Table 1.7.3).

Table 17.10.8.3 TRANSVERSE REINFORCEMENT

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Critical Region $S_h = \min(6\phi_l, 1/4b, 150\text{mm})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elsewhere</td>
<td>$S_h = \min(8\phi_l, 1/2b, 200\text{mm})$</td>
</tr>
</tbody>
</table>

DUCTILITY LEVEL III Critical Region $l_c = \max(h, l/6, 450\text{mm})$ (Fig. 17.10.8.6)
17.10.8.4 Beam - Column Joints

17.10.8.4.1 Confinement

(1) DL I and DL II Structures

The horizontal transverse confinement reinforcement in beam - column joints shall not be less than that required for the columns.

(2) DL III Structures

(a) The horizontal transverse confinement reinforcement in beam - column joints shall not be less than that required for the columns with the exception of joints connecting beams at all four column faces that are designed according to Clause 17.10.7.2(1)(b)(ii) or (iii) in which case the transverse joint reinforcement may be reduced to one half of that required for the columns, but in no case shall the stirrup tie spacing in the joint core exceed ten times the diameter of the column bar, or 200 mm, whichever is less.

(b) When the width of the column is larger than the effective joint width specified in Clause 17.10.7.2(1)(a), all flexural reinforcement in the column that is required to interact with the narrow beam shall be placed within the effective joint area, bj.hc. Additional longitudinal column reinforcement shall be placed outside this effective area.

17.10.8.5 Structural Walls

17.10.8.5.1 Geometrical Constraints

(1) General

(i) Wall thickness shall not be less than 150 mm.

(ii) Openings in the walls not regularly arranged to form coupled walls shall be preferably avoided, unless their influence on the behaviour, of the wall under seismic action is either insignificant or accounted for by rational analysis.

(2) DL III Structures

In addition to the requirements in 17.10.8.5.1 (1) - DL III structures shall also satisfy the following.

(a) the height \( h_w \) to width \( l_w \) ratio shall not be less than 2;
**Fig. 17.10.8.10 - Definition of Vertical Reinforcement Ratio**

### 17.10.8.5.2 Longitudinal Reinforcement

(a) The vertical reinforcement ratio in any part of the clause shall not be less than 0.25% or greater than 4% (see Fig. 17.10.8.10).

(b) At least two orthogonal grids of reinforcement shall be used one near each side of the wall.

(c) The diameter of the bars used in any part of a wall shall not exceed \( b/10 \)

(d) The maximum spacing between bars shall be 300mm except where the clause is required to be confined, in which case the spacing shall not exceed 200 mm.

(e) **Curtailing:** Vertical flexural reinforcement shall be curtailed in accordance with the bending moment envelope, allowing for the development lengths of the curtailed bars.

(f) **Splicing:** Splicing of the vertical reinforcement in potential areas of yielding

(See 17.10.8.5.3(1)) shall be avoided whenever possible. In no case shall more than one third of such reinforcement be spliced in those areas. Special care shall be taken for splicing of the main (flexural) vertical bars. The splices should be staggered in the longitudinal direction at least twice the spliced length.

(g) **Construction joints:** The ratio of vertical reinforcement crossing a construction joint shall be such as to provide for the transfer of the entire shear capacity of concrete and is given by the expression:

\[
\rho_v = \frac{1.3 \cdot f_{ctm} - 0.7 \cdot N_d/A_g}{f_{yk}} > 0.0025
\]

.................17.10.8.7

where:

\[
\rho_v = \frac{A_{st}}{b \cdot l_w}
\]

with \( A_{st} \) = total vertical wall reinforcement, including that in boundary elements provided to resist flexure.

\( A_g \) is the gross area of the effective wall clause including boundary elements.

\( N_d \) is the minimum compression force in the wall. Tension shall be taken as negative.

### 17.10.8.5.3 Transverse Reinforcement

(1) **General**

The requirement for minimum reinforcement ratio, maximum diameter and maximum spacing, shall be as for longitudinal reinforcement (Clause 17.10.8.5.2)

(2) **Zones with special transverse reinforcement**

(a) The zones of walls requiring special reinforcement as specified in (b) below are defined as follows:

(i) in the vertical direction, they shall extend from the base over the probable plastic hinge length, which for the purpose is assumed to be the greater of; the length \( l_w \) or 1/6 of the height \( h_w \) of the wall.

(ii) in the plan clause whenever the computed concrete strain exceeds the value

\[ \varepsilon_{cu}/3 \]

The strain profile over the clause shall correspond to development of its flexural strength under the maximum design axial compression force occurring for a load combination including the seismic action (Fig. 17.10.8.11)
(b) The amount of special transverse reinforcement to be provided is a function of the computed depth of the neutral axis: \( x \) in the base clause of the wall, and of the selected ductility level as follows:

(i) DL II Structures

The critical neutral axis depth, computed for the most adverse, design bending moment, \( d \), is given by:

\[
\bar{\chi} = 0.2 \left( \frac{M^*_{ud}}{M_d} \right) \cdot \frac{l_w}{h_w} \ ...	ext{17.10.8.8}
\]

when: 
\( \chi \leq \bar{\chi} \) – Transverse reinforcement shall satisfy the minimum requirements set forth in Clause 17.10.8.5.3. Cross ties to restrain longitudinal bars shall be used in accordance with BS 8110 (1985)

\( \chi > \bar{\chi} \) – Transverse reinforcement shall satisfy the requirements of Clause 17.10.8.3.4(3) (Ductility Level II columns in critical regions).

(ii) DL III Structures

The critical neutral axis depth, computed for the most adverse bending moment \( M_d \), is given by:

\[
\bar{\chi} = 0.1 \left( \frac{M^*_{ud}}{M_d} \right) \cdot \frac{6l_{11}}{l_w} \ ...	ext{17.10.8.11}
\]

\( \rho_s = \lambda_1 \cdot \frac{f_{ck}}{f_{yk}} \) ..................17.10.8.10

or

\[
\rho_s = \lambda_2 \left( \frac{A_g}{A_c} - 1 \right) \frac{f_{ck}}{f_{yk}} \ ...... \text{17.10.8.11}
\]

where the values of \( \lambda_1 \) and \( \lambda_2 \) are given in the following Table 17.10.8.4 as functions of neutral axis depth ratio.

<table>
<thead>
<tr>
<th>TABLE 17.10.8.4</th>
<th>VALUES OF ( \lambda_1 ) AND ( \lambda_2 ) IN EQUATIONS 17.10.8.10 AND 17.10.8.11</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi / l_w )</td>
<td>0.1</td>
</tr>
<tr>
<td>( \lambda_1 )</td>
<td>0.07</td>
</tr>
<tr>
<td>( \lambda_2 )</td>
<td>0.18</td>
</tr>
</tbody>
</table>

The volumetric ratio is defined as

\[
\rho = \frac{A'_{sh}}{S_h h'} \ ...	ext{17.10.8.12}
\]

where \( h' = \) dimension of wall concrete core measured perpendicular to the direction
of hoop bars to outside of peripheral hoops

\[ A'_{sh} = \text{total steel area of hoop bars and supplementary cross ties in direction under consideration, with spacing } S_h \]

### 17.10.8.5.4 Coupling Beams

(a) The diagonal reinforcement in each direction shall be enclosed by rectangular stirrups, hoops or spirals in accordance with Clause 5.10.8.3.4(4), however their spacing or pitch shall not exceed 100mm.

(b) Minimum thickness for diagonally reinforced beams shall be 200 mm. The anchorage length of diagonal reinforcement in the adjacent wall be increased by 50% of the lengths prescribed in BS 8110 (1985) (Fig. 5.10.8.12).

![Fig. 17.10.8.12](image)

### 17.10.8.6 Anchorage and Splicing of Reinforcement

#### 17.10.8.6.1 General

In addition to the rules of BS 8110 the following requirements shall be satisfied in order to ensure reliable behaviour during cyclic loading reversals caused by seismic action:

(a) All reinforcement bars should be considered to be in insufficient bond conditions except when anchorage is made in regions confined by means of special transverse reinforcement where good bond condition can be assumed.

(b) All bars should be able to develop their maximum strength \((\gamma_n f_{yk})\) when a plastic hinge is formed.

#### 17.10.8.6.2 Flexural Members: Anchorage of Longitudinal Reinforcement

(a) Flexural members framing into opposite sides of a column shall have top and bottom reinforcement provided at ends of members continuous through the column where possible.

(b) When top or bottom reinforcement cannot be continuous through the column due to the variations in flexural members cross clause, and in exterior columns, the reinforcement shall be anchored within the beam column connection in accordance with the following:

(i) Reinforcement shall be extended to the far face of the confined region and anchored to develop its yield strength.

(ii) Every bar shall terminate with a standard 90-degree hook or equivalent anchorage device, as near as practically possible to the far face of the column core. Top bars should be bent down and bottom bars bent up.

(iii) Development length of beam reinforcement shall be computed beginning at a distance of 10 \(\phi\) from the near face column.

(c) For DL III Structures when beams frame into opposite sides of a column, the maximum diameter of the longitudinal beam bars which are continuous through the column should not exceed the following fractions of the column depth (parallel to the bar) in Table 17.10.8.5

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Fraction of (h_c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S220 smooth</td>
<td>1/35</td>
</tr>
<tr>
<td>S220 deformed</td>
<td>1/20</td>
</tr>
<tr>
<td>S400 deformed</td>
<td>1/30</td>
</tr>
</tbody>
</table>
17.10.8.3 Columns: Anchorage of Longitudinal Reinforcement

(a) The maximum diameter of longitudinal column bars which are continuous through a joint shall not exceed the following fractions of maximum depth of the beams framing into the column. (Table 17.10.8.6)

Table 17.10.8.6

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>Fraction of $h_b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>S220 smooth</td>
<td>1/25</td>
</tr>
<tr>
<td>S220 deformed</td>
<td>1/15</td>
</tr>
<tr>
<td>S220 deformed</td>
<td>1/25</td>
</tr>
</tbody>
</table>

When hinges are permitted to form in columns the values indicated in Clause 17.10.8.6.2 shall be applied.

(b) The anchorage of a column bar into an inter-clause beam shall be made by a horizontal 90-degree standard hook or equivalent device, as near the far face of the beam as practically possible. The direction of the horizontal leg of the standard hook must always be towards the core of the joint.

(c) When columns terminate at joints at the top of frames or at joints between columns and foundation members, the anchorage of the longitudinal column bars into the joint region shall be assumed to begin at a distance equal to one half of the depth of the beam, or 10φ, whichever is less from the face at which the column bar enters the beam. (Fig 17.10.8.13)

17.10.8.4 Splices of Longitudinal Reinforcement

(a) Splices are not permitted within beam-column joints or within potential plastic hinge regions.

(b) If it can be shown that plastic hinge cannot develop, splices are permitted in the end clauses of columns, provided that transverse reinforcement spaced vertically no further than 6 bar diameters, is present.

(c) Stirrup-ties shall be provided over the length of all lap splices of reinforcement in beams and columns. The maximum spacing of the stirrup-ties shall not exceed 10 times the diameter of the bar being spliced.

For DL III structures the maximum spacing shall also not exceed 150 mm.

(d) Welded splices or approved mechanical connections conforming with BS 8110 (1985) may be used, provided that not more than alternate bars in each layer of longitudinal reinforcement are spliced at a clause, and the distance between splices of adjacent bars is 600 mm or more measured along the longitudinal axis of the frame component.

17.10.8.5 Anchorage and Splicing of Transverse Reinforcement

(a) Transverse hoop reinforcement shall be anchored by at least a 135° bent around a
longitudinal bar with a minimum extension at the face end of 10 bar diameters.

Alternatively, the ends of the hoops can be spliced by welds capable of developing the full strength of the bar.

(b) Transverse reinforcement shall not be lap-spliced in cover concrete with beam–column joints or within potential plastic hinge regions. Deformed bars shall be used for lap splices.

(c) When the anchorage for a spiral terminates with a 135° bend around a longitudinal bar, the extension beyond the bend shall be at least 10 spiral bar diameters.

**APPENDIX A**

**SCHEDULE OF UNIT WEIGHT OF BUILDING MATERIALS**

**Weights of concrete Table 1A**

<table>
<thead>
<tr>
<th>Lightweights concrete</th>
<th>Non-reinforced plain or mass concrete</th>
<th>Normal weight Aggregate:</th>
<th>kN/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>limestone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>gravel</td>
<td>22.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>broken brick</td>
<td>21.2 to 23.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>other crushed stone</td>
<td>22.0 to 23.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19.6 (av)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22.8 to 24.4</td>
</tr>
<tr>
<td>Reinforced concrete</td>
<td>Nominal weight</td>
<td></td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td>Reinforcement: 1%</td>
<td></td>
<td>22.6 to 24.2</td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td></td>
<td>23.1 to 24.7</td>
</tr>
<tr>
<td></td>
<td>4%</td>
<td></td>
<td>24.0 to 25.6</td>
</tr>
<tr>
<td></td>
<td>Solid slabs – Thickness (floors, walls, 75mm etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100mm</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150mm</td>
<td>2.40</td>
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</tr>
<tr>
<td></td>
<td>250mm</td>
<td>3.60</td>
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</tr>
<tr>
<td></td>
<td>300mm</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ribbed slabs</td>
<td>7.20</td>
<td></td>
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<tr>
<td></td>
<td>125mm</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150mm</td>
<td>2.15</td>
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</tr>
<tr>
<td></td>
<td>225mm</td>
<td>2.75</td>
<td></td>
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<tr>
<td>Aggregate or type</td>
<td>Compressive strength N/mm²</td>
<td>kN/ m²</td>
<td></td>
</tr>
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<td>------------------</td>
<td>-----------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Expanded clay or shale</td>
<td>5.6 to 8.4</td>
<td>9.4 to 11.8</td>
<td></td>
</tr>
<tr>
<td>-ditto - structural</td>
<td>13.8 to 34.5</td>
<td>13.4 to 18.1</td>
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<tr>
<td>Vermiculite (expanded mica)</td>
<td>0.5 to 3.5</td>
<td>3.9 to 11.0</td>
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</tr>
<tr>
<td>No-fines (gravel)</td>
<td>-</td>
<td>15.7 to 18.9</td>
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<tr>
<td>Cellular (aerated or gas concrete)</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellular structural</td>
<td>10.3 to 15.5</td>
<td>3.9 (min.) to 14.1 to 15.7</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Concrete block and brick walls</th>
<th>kN/ m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandcrete block: solid</td>
<td>17.3</td>
</tr>
<tr>
<td>Lightweight aggregates: solid</td>
<td>13.2</td>
</tr>
<tr>
<td>Brickwork (nominal)</td>
<td>21.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other products</th>
<th>kN/m²</th>
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<tbody>
<tr>
<td>Paving slabs (flags)</td>
<td></td>
</tr>
<tr>
<td>50mm thick</td>
<td>1.15</td>
</tr>
<tr>
<td>Roofing tiles: plain</td>
<td>0.6 to 0.9</td>
</tr>
<tr>
<td>inter-locking</td>
<td>0.6</td>
</tr>
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*To convert values in kN to values in kg, multiply by 102*

---

<table>
<thead>
<tr>
<th>Weights of constructional materials</th>
<th>Table 2A</th>
</tr>
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<tr>
<td>Concrete Brickwork etc.</td>
<td>See Table 1A</td>
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<tr>
<td>Tarmacadam</td>
<td>KN/m³</td>
</tr>
<tr>
<td>Clay floor tiles</td>
<td>N/m²</td>
</tr>
<tr>
<td>Damp-proof course</td>
<td>575</td>
</tr>
<tr>
<td></td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>N/m² mm per thickness</td>
</tr>
<tr>
<td>Material</td>
<td>Density at 12% moisture content</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Macadam (waterbound)</td>
<td>22.6</td>
</tr>
<tr>
<td>Vermiculite3 (aggregate)</td>
<td>25.1</td>
</tr>
<tr>
<td>Terracotta</td>
<td>0.8</td>
</tr>
<tr>
<td>Glass</td>
<td>20.8</td>
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<tr>
<td>Cork: granular</td>
<td>26.7</td>
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<tr>
<td>Cork: compressed</td>
<td>1.2</td>
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<tr>
<td>Cork</td>
<td>3.8</td>
</tr>
<tr>
<td>density at 12% moisture content</td>
<td></td>
</tr>
<tr>
<td>Abura</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Afara or limba</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>African walnut</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Afromosia</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Afzelia</td>
<td>7.9 to 10.2</td>
</tr>
<tr>
<td>Agba</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Albizia (A.ferruginea)</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Alstonia</td>
<td>3.1</td>
</tr>
<tr>
<td>Antiaris</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Avodire</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Ayan</td>
<td>3.1</td>
</tr>
<tr>
<td>Canarium, African</td>
<td>3.1</td>
</tr>
<tr>
<td>Celtis</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Dahoma</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Danta</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Ekki</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Esia</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Mansonia</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Chipboard</td>
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<tr>
<td>Plywood</td>
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</tr>
<tr>
<td>Fibreboard</td>
<td></td>
</tr>
<tr>
<td>Wood-wool</td>
<td></td>
</tr>
<tr>
<td>Plaster-wool</td>
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</tr>
<tr>
<td>Water boarding</td>
<td></td>
</tr>
<tr>
<td>Gedu nohor</td>
<td></td>
</tr>
<tr>
<td>Guarea (cedrata)</td>
<td></td>
</tr>
<tr>
<td>Guarea (thomsonii)</td>
<td></td>
</tr>
<tr>
<td>Idigbo</td>
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<tr>
<td>Ilomba</td>
<td></td>
</tr>
<tr>
<td>Iroko</td>
<td></td>
</tr>
<tr>
<td>Mahogany, African</td>
<td></td>
</tr>
<tr>
<td>Makore</td>
<td></td>
</tr>
<tr>
<td>Okwen</td>
<td></td>
</tr>
<tr>
<td>Opepe</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Density (g/mm²)</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Mubura</td>
<td>10.2</td>
</tr>
<tr>
<td>Miangori</td>
<td>7.9 to 10.2</td>
</tr>
<tr>
<td>Obeche</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Odoko</td>
<td>6.3 to 7.7</td>
</tr>
<tr>
<td>Ogea</td>
<td>4.7 to 6.1</td>
</tr>
<tr>
<td>Okan</td>
<td>3.1 to 6.1</td>
</tr>
<tr>
<td>Natural stone (solid)</td>
<td></td>
</tr>
<tr>
<td>Granite</td>
<td>25.1 to 28.7</td>
</tr>
<tr>
<td>Sandstone</td>
<td>22.0 to 23.6</td>
</tr>
<tr>
<td>slate</td>
<td>28.3</td>
</tr>
<tr>
<td>Natural stone (solid)</td>
<td></td>
</tr>
<tr>
<td>iron: cast</td>
<td>70.7</td>
</tr>
<tr>
<td>wrought</td>
<td>75.4</td>
</tr>
<tr>
<td>steel (see also below)</td>
<td></td>
</tr>
<tr>
<td>copper: cast</td>
<td>85.6</td>
</tr>
<tr>
<td>: wrought</td>
<td>87.7</td>
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<tr>
<td>Brass</td>
<td>83.3</td>
</tr>
<tr>
<td>Bronze</td>
<td>87.7</td>
</tr>
<tr>
<td>Aluminum</td>
<td>27.2</td>
</tr>
<tr>
<td>Lead</td>
<td>111.0</td>
</tr>
<tr>
<td>Zinc (rolled)</td>
<td>70.0</td>
</tr>
<tr>
<td>g/mm² per metre</td>
<td>7.85</td>
</tr>
<tr>
<td>Structural steel work</td>
<td></td>
</tr>
<tr>
<td>Net weight of member</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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</table>

See Table 3A

N/m

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<tr>
<th>Material</th>
<th>Density (g/mm²)</th>
<th>Uses</th>
</tr>
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<tbody>
<tr>
<td>Steel bars</td>
<td>7.85</td>
<td>Plate-web girders</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof trusses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel stairs: industrial</td>
</tr>
<tr>
<td>Type in wide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel tube:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50mm in bore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas piping: 20mm</td>
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### Weight of roofs

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight per (m^2) of slope of roof (N/m²)</th>
</tr>
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<tbody>
<tr>
<td>Net</td>
<td>including normal laps and fastenings</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Table 3A</strong></td>
<td></td>
</tr>
<tr>
<td>Aluminum sheet corrugated 18. S.W.G</td>
<td>37.8</td>
</tr>
<tr>
<td>Aluminum sheet, corrugated 20 S.W.G</td>
<td>28.7</td>
</tr>
<tr>
<td>Aluminum sheet corrugated 22. S.W.G</td>
<td>22.0</td>
</tr>
<tr>
<td>Aluminum sheet corrugated 24. S.W.G</td>
<td>17.2</td>
</tr>
<tr>
<td>Aluminum sheet, flat 18 S.W.G</td>
<td>33.5</td>
</tr>
<tr>
<td>Aluminum sheet, flat 20 S.W.G</td>
<td>24.9</td>
</tr>
<tr>
<td>Aluminum sheet, flat 22 S.W.G</td>
<td>19.6</td>
</tr>
<tr>
<td>Aluminum sheet, flat 24 S.W.G</td>
<td>15.3</td>
</tr>
<tr>
<td>Asbestos cement sheets, corrugated 6mm thick</td>
<td>135</td>
</tr>
<tr>
<td>Asbestos cement sheets, flat 5mm thick</td>
<td>80</td>
</tr>
<tr>
<td>Asbestos cement sheets, flat 6mm thick</td>
<td>110</td>
</tr>
<tr>
<td>Asbestos cement sheets, flat 10mm thick</td>
<td>170</td>
</tr>
<tr>
<td>Asbestos cement sheets, flat 12mm thick</td>
<td>220</td>
</tr>
<tr>
<td>Copper sheeting 16 S.W.G</td>
<td>145</td>
</tr>
<tr>
<td>Copper sheeting 18 S.W.G</td>
<td>110</td>
</tr>
<tr>
<td>Copper sheeting 20 S.W.G</td>
<td>80</td>
</tr>
<tr>
<td>Copper sheeting 22 S.W.G</td>
<td>65</td>
</tr>
<tr>
<td>Copper sheeting 24 S.W.G</td>
<td>50</td>
</tr>
<tr>
<td>Material</td>
<td>Dry</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Roofing felt, 3-ply</td>
<td>25</td>
</tr>
<tr>
<td>Roofing felt, 2-ply</td>
<td>20</td>
</tr>
<tr>
<td>Roofing felt, 1-ply</td>
<td>15</td>
</tr>
<tr>
<td>Shingles (excluding battens)</td>
<td></td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 18GB</td>
<td>110</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 20GB</td>
<td>90</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 22GB</td>
<td>70</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 24GB</td>
<td>55</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 26GB</td>
<td>45</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 28GB</td>
<td>35</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 18GB</td>
<td>100</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 20GB</td>
<td>80</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 22GB</td>
<td>60</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 24GB</td>
<td>50</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 26GB</td>
<td>40</td>
</tr>
<tr>
<td>Shingles (excluding battens)</td>
<td></td>
</tr>
<tr>
<td>Roofing felt, 3-ply</td>
<td>25</td>
</tr>
<tr>
<td>Roofing felt, 2-ply</td>
<td>20</td>
</tr>
<tr>
<td>Roofing felt, 1-ply</td>
<td>15</td>
</tr>
<tr>
<td>Shingles (excluding battens)</td>
<td></td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 18GB</td>
<td>110</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 20GB</td>
<td>90</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 22GB</td>
<td>70</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 24GB</td>
<td>55</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 26GB</td>
<td>45</td>
</tr>
<tr>
<td>Steel sheet, galvanized, corrugated 28GB</td>
<td>35</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 18GB</td>
<td>100</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 20GB</td>
<td>80</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 22GB</td>
<td>60</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 24GB</td>
<td>50</td>
</tr>
<tr>
<td>Steel sheet, galvanized, flat 26GB</td>
<td>40</td>
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**Table 3A (cont’d)**

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<tr>
<th>Material</th>
<th>Dry</th>
<th>Wet</th>
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</thead>
<tbody>
<tr>
<td>Steel sheet, galvanized, flat 28BG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thatching, 300mm nominal thickness - dry</td>
<td>30</td>
<td>410</td>
</tr>
<tr>
<td>Thatching, 300mm nominal thickness - wet</td>
<td></td>
<td>530</td>
</tr>
<tr>
<td>Roofing, burnt clay Marseilles type (excluding battens)</td>
<td>430</td>
<td></td>
</tr>
<tr>
<td>Tiles, roofing, burnt clay Etruscna type (excluding battens)</td>
<td>570</td>
<td></td>
</tr>
<tr>
<td>Tiles, roofing, burnt clay, Broseley type (excluding battens)</td>
<td>670</td>
<td></td>
</tr>
</tbody>
</table>
Reinforced concrete slabs, concrete tiles etc. | 720 |
| See Table 1A |

<table>
<thead>
<tr>
<th>Spacing of trusses</th>
<th>3.0m</th>
<th>4.5m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate weights of steel roof trusses in N/m² of plan area of roof</td>
<td>Span of trusses</td>
<td></td>
</tr>
<tr>
<td>7.5m</td>
<td>9m</td>
<td>12m</td>
</tr>
<tr>
<td>95</td>
<td>120</td>
<td>132</td>
</tr>
<tr>
<td>72</td>
<td>72</td>
<td>84</td>
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**Weights of stored materials**

<table>
<thead>
<tr>
<th>Liquids and semi-liquids</th>
<th>KN/m³</th>
<th>Liquids and semi-liquids</th>
<th>KN/m³</th>
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</thead>
<tbody>
<tr>
<td>Acids: acetic</td>
<td>nitric</td>
<td>10.4</td>
<td>Mineral oils: naptha</td>
</tr>
<tr>
<td></td>
<td>sulphuric</td>
<td>15.1</td>
<td>Paraffin (kerosene)</td>
</tr>
<tr>
<td></td>
<td>alcohol (commercial)</td>
<td>18.1</td>
<td>Petrol (gasoline)</td>
</tr>
<tr>
<td></td>
<td>ammonia</td>
<td>7.9</td>
<td>Petroleum oil</td>
</tr>
<tr>
<td></td>
<td>beer: in bulk</td>
<td>8.8</td>
<td>Pulp (wood)</td>
</tr>
<tr>
<td></td>
<td>bottled (in cases)</td>
<td>10.0</td>
<td>Slurry: cement</td>
</tr>
<tr>
<td></td>
<td>in barrels</td>
<td>4.6</td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td>benzene, benzol</td>
<td>5.5</td>
<td>Sewage</td>
</tr>
<tr>
<td></td>
<td>bitumen (prepared)</td>
<td>8.6</td>
<td>Tar, pitch</td>
</tr>
<tr>
<td></td>
<td>methylated spirit</td>
<td>13.7</td>
<td>Turpentine</td>
</tr>
<tr>
<td></td>
<td>linseed oil milk</td>
<td>8.2</td>
<td>Water: fresh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.8</td>
<td>Sea—water</td>
</tr>
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<td></td>
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<td>10.2</td>
<td>Wine: in bulk</td>
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<td>Material</td>
<td>Bottled (in cases)</td>
<td>Bottled (in cases)</td>
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</tr>
<tr>
<td>Brewery’s grains (wet)</td>
<td>5.5</td>
<td>Lime (slated) dry</td>
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</tr>
<tr>
<td>Bricks (stacked)</td>
<td>17.3</td>
<td>wet</td>
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</tr>
<tr>
<td>Clinker</td>
<td>9.4 to 10.2</td>
<td>Paper (packed)</td>
<td></td>
</tr>
<tr>
<td>Cotton (in bales)</td>
<td>2.4 to 5.5</td>
<td>Waste (pressed)</td>
<td></td>
</tr>
<tr>
<td>Flour: in bulk</td>
<td>7.1</td>
<td>Salt: dry</td>
<td></td>
</tr>
<tr>
<td>In sacks</td>
<td>6.3</td>
<td>Loose</td>
<td></td>
</tr>
<tr>
<td>Hops (in sacks)</td>
<td>1.7</td>
<td>Sawdust</td>
<td></td>
</tr>
<tr>
<td>Ice</td>
<td>9.0</td>
<td>Slag: basic</td>
<td></td>
</tr>
<tr>
<td>Bottled goods (in cases)</td>
<td>8.8</td>
<td>Crushed</td>
<td></td>
</tr>
<tr>
<td>Eggs in bulk</td>
<td>10.7</td>
<td>Foamed</td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>7.1</td>
<td>Sugar (loose)</td>
<td></td>
</tr>
<tr>
<td>Tinned goods (in cases)</td>
<td>9.4</td>
<td>Tea (in chests)</td>
<td></td>
</tr>
</tbody>
</table>

To convert values in kN to values in kg, multiply by 102
PART 18: SOILS AND FOUNDATIONS

User notes:
About this part: Part 18 provides criteria for geotechnical and structural considerations in the selection, design and installation of foundation systems to support the loads imposed by the structure above. This part includes requirements for soils investigation and site preparation for receiving a foundation, including the load-bearing values for soils and protection for the foundation. Clause 18.8 addresses the basic requirements for all foundation types while subsequent clauses address foundation requirements that are specific to shallow foundations and deep foundations.

18.1 GENERAL

18.1.1 Scope.
The provisions of this part shall apply to building and foundation systems.

The provisions of this part shall apply to the Geotechnical assessment of sites for building projects.

18.2 DESIGN BASIS

18.2.1 General.
Allowable bearing pressures, allowable stresses and design formulas provided in this part shall be used with the allowable stress design load combinations specified in this Code. The quality and design of materials used structurally in excavations and foundations shall comply with the requirements specified in Part 17, 20, 22, 23 and 24. Excavations and fills shall comply with Part 34.

18.3 GEOTECHNICAL INVESTIGATIONS

18.3.1 General.
Geotechnical investigations shall be conducted in accordance with Clause 18.3.2 and reported in accordance with Clause 18.3.6. Where required by the building official or where geotechnical investigations involve in-situ testing, laboratory testing or engineering calculations, such investigations shall be conducted by a registered Geotechnical Engineer.

18.3.2 Investigations required.
Geotechnical investigations shall be conducted in accordance with Clauses 18.3.3 through 18.3.5.

18.3.3 Method of investigation.
Soil classification shall be based on observation and any necessary tests of the materials disclosed by borings, test pits or other subsurface exploration made in appropriate locations. Additional studies shall be made as necessary to evaluate slope stability, soil strength, position and adequacy of load-bearing soils, the effect of moisture variation on soil-bearing capacity, compressibility, liquefaction and expansiveness.

18.3.3.1 Scope of investigation.
The scope of the geotechnical investigation including the number and types of borings or soundings, the equipment used to drill or sample, the in-situ testing equipment and the laboratory testing program shall be determined by a registered Geotechnical Engineer.

18.3.4 Qualified representative.
The investigation procedure and apparatus shall be in accordance with generally accepted engineering practice. The registered Geotechnical Engineer shall have a fully qualified representative on site during all boring or sampling operations.

18.3.5 Investigated conditions.
Geotechnical investigations shall be conducted as indicated in Clauses 18.3.5.1 through 18.3.5.12.

18.3.5.1 Classification.
Soil materials shall be classified in accordance with ASTM D2487 (Unified Soil Classification System) or its equivalent.
18.3.5.2 Questionable soil.

Where the classification, strength or compressibility of the soil is in doubt or where a load-bearing value superior to that specified in this Code is claimed, the building official shall be permitted to require that a geotechnical investigation be conducted.

18.3.5.3 Expansive soil.

In areas likely to have expansive soil, the building official shall require soil tests to determine where such soils do exist.

Soils meeting all four of the following provisions shall be considered to be expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity index (PI) of 15 or greater, determined in accordance with ASTM D4318.
2. More than 10 percent of the soil particles pass a No. 200 sieve (75 µm), determined in accordance with ASTM D422.
3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D422.
4. Expansion index greater than 20, determined in accordance with ASTM D4829.

18.3.5.4 Ground-water table.

A subsurface soil investigation shall be performed to determine whether the existing ground-water table is above or within 1524 mm (5 feet) below the elevation of the lowest floor level where such floor is located below the finished ground level adjacent to the foundation.

The Geotechnical investigation shall report presence of ground water possible implications and the recommendations to address any issues.

18.3.5.5 Deep foundations.

Where deep foundations will be used, a geotechnical investigation shall be conducted and shall include all of the following, unless sufficient data on which to base the design and installation is otherwise available:

1. Recommended deep foundation types and installed capacities.
2. Recommended center-to-center spacing of deep foundation elements.
3. Driving criteria.
4. Installation procedures.
5. Field inspection and reporting procedures (to include procedures for verification of the installed bearing capacity where required).
6. Load test requirements.
7. Suitability of deep foundation materials for the intended environment.
8. Designation of bearing stratum or strata.
9. Reductions for group action, where necessary.

18.3.5.6 Rock strata.

Where subsurface explorations at the project site indicate variations in the structure of rock on which foundations are to be constructed, a sufficient number of borings shall be drilled to sufficient depths to assess the competency of the rock and its load-bearing capacity.

18.3.5.7 Excavation near foundations.

Where excavation will reduce support from any foundation, a registered geotechnical engineer shall prepare an assessment of the structure as determined from examination of the structure, the review of available design documents and, if necessary, excavation of test pits. The registered design professional shall determine the requirements for underpinning and protection and prepare site-specific plans,
details and sequence of work for submission. Such support shall be provided by underpinning, sheeting and bracing, or by other means acceptable to the building official.

18.3.5.8 Compacted fill material.
Where shallow foundations will bear on compacted fill material more than 305 mm (12 inches) in depth, a geotechnical investigation shall be conducted and shall include all of the following:

1. Specifications for the preparation of the site prior to placement of compacted fill material.
2. Specifications for material to be used as compacted fill.
3. Test methods to be used to determine the maximum dry density and optimum moisture content of the material to be used as compacted fill.
4. Maximum allowable thickness of each lift of compacted fill material.
5. Field test method for determining the in-place dry density of the compacted fill.
6. Minimum acceptable in-place dry density expressed as a percentage of the maximum dry density determined in accordance with Item 3.
7. Number and frequency of field tests required to determine compliance with Item 6.

18.3.5.9 Selected fill material (SFM).
Where shallow foundations will bear on selected fill material (SFM), a geotechnical investigation shall be conducted and shall include all of the following:

1. Specifications for the preparation of the site prior to placement of the CLSM.
2. Specifications for the (SFM).
3. Laboratory or field test method(s) to be used to determine the compressive strength or bearing capacity of the (SFM).
4. Test methods for determining the acceptance of the (SFM) in the field.
5. Number and frequency of field tests required to determine compliance with Item 4.

18.3.5.10 Alternate setback and clearance.
Where setbacks or clearances other than those required in Clause 18.8.7 are desired, the building official shall be permitted to require a geotechnical investigation by a registered design professional to demonstrate that the intent of Clause 18.8.7 would be satisfied. Such an investigation shall include consideration of material, height of slope, slope gradient, load intensity and erosion characteristics of slope material.

18.3.5.11 Seismic Design Categories C through F.
For structures assigned to Seismic Design Category C, D, E or F, a geotechnical investigation shall be conducted, and shall include an evaluation of all of the following potential geologic and seismic hazards:

1. Slope instability.
2. Liquefaction.
3. Total and differential settlement.
4. Surface displacement due to faulting or seismically induced lateral spreading or lateral flow.

18.3.5.12 Seismic Design Categories
For structures assigned to Seismic Design Category as referred to this Code on Seismic Zones. The geotechnical investigation required by clause 18.3.5.11 shall include all of the following as applicable:
1. The determination of dynamic seismic lateral earth pressures on foundation walls and retaining walls supporting more than 1.83 m (6 feet) of backfill height due to design earthquake ground motions.

2. The potential for liquefaction and soil strength loss evaluated for site peak ground acceleration, earthquake magnitude and source characteristics consistent with the maximum considered earthquake ground motions. Peak ground acceleration shall be determined based on one of the following:

2.1. A site-specific study in accordance with this Code

3. An assessment of potential consequences of liquefaction and soil strength loss including, but not limited to, the following:

3.1. Estimation of total and differential settlement.

3.2. Lateral soil movement.

3.3. Lateral soil loads on foundations.

3.4. Reduction in foundation soil-bearing capacity and lateral soil reaction.

3.5. Soil downdrag and reduction in axial and lateral soil reaction for pile foundations.

3.6. Increases in soil lateral pressures on retaining walls.

4. Discussion of mitigation measures such as, but not limited to, the following:

4.1. Selection of appropriate foundation type and depths.

4.2. Selection of appropriate structural systems to accommodate anticipated displacements and forces.

4.3. Ground stabilization.

4.4. Any combination of these measures and how they shall be considered in the design of the structure.

18.3.6 Reporting.

Where geotechnical investigations are required, a written report of the investigations shall be submitted to the building official by the permit applicant at the time of permit application. This geotechnical report shall include, but need not be limited to, the following information:

1. A plot showing the location of the soil investigations.

2. A complete record of the soil boring and penetration test logs and soil samples.

3. A record of the soil profile.

4. Elevation of the water table, if encountered.

5. Recommendations for foundation type and design criteria, including but not limited to: bearing capacity of natural or compacted soil; provisions to mitigate the effects of expansive soils; mitigation of the effects of liquefaction, differential settlement and varying soil strength; and the effects of adjacent loads.


7. Deep foundation information in accordance with Clause 18.3.5.5.

8. Special design and construction provisions for foundations of structures founded on expansive soils, as necessary.

9. Compacted fill material properties and testing in accordance with Clause 18.3.5.8.

10. Controlled low-strength material properties and testing in accordance with Clause 18.3.5.9.
18.4 EXCAVATION, GRADING AND FILL

18.4.1 Excavation near foundations.
Excavation for any purpose shall not reduce vertical or lateral support for any foundation or adjacent foundation without first underpinning or protecting the foundation against detrimental lateral or vertical movement, or both.

18.4.2 Underpinning.
Where underpinning is chosen to provide the protection or support of adjacent structures, the underpinning system shall be designed and installed in accordance with provisions of this part and Part 34.

18.4.2.1 Underpinning sequencing.
Underpinning shall be installed in a sequential manner that protects the neighboring structure and the working construction site. The sequence of installation shall be identified in the approved construction documents.

18.4.3 Placement of backfill.
The excavation outside the foundation shall be backfilled with soil that is free of organic material, construction debris, cobbles and boulders or with a selected fill material (SFM). The backfill shall be placed in lifts and compacted in a manner that does not damage the foundation or the waterproofing or dampproofing material.

Exception: SFM need not be compacted.

18.4.4 Site grading.
The ground immediately adjacent to the foundation shall be sloped away from the building at a slope of not less than one unit vertical in 20 units horizontal (5-percent slope) for a minimum distance of 10 feet (3048 mm) measured perpendicular to the face of the wall. If physical obstructions or plot lines prohibit 3048 mm (10 feet) of horizontal distance, a 5-percent slope shall be provided to an approved alternative method of diverting water away from the foundation. Swales used for this purpose shall be sloped not less than 2 percent where located within 3048 mm (10 feet) of the building foundation. Impervious surfaces within 3048 mm (10 feet) of the building foundation shall be sloped not less than 2 percent away from the building.

Exceptions:

1. Where climatic or soil conditions warrant, the slope of the ground away from the building foundation shall be permitted to be reduced to not less than one unit vertical in 48 units horizontal (2-percent slope).

2. Impervious surfaces shall be permitted to be sloped less than 2 percent where the surface is a door landing or ramp that is required to comply with Clause 11.10.1.5, 11.12.3 or 11.12.6.1.

The procedure used to establish the final ground level adjacent to the foundation shall account for additional settlement of the backfill.

18.4.5 Grading and fill in flood hazard areas.
In flood hazard areas established in this Code, grading, fill, or both, shall not be approved:

1. Unless such fill is placed, compacted and sloped to minimize shifting, slumping and erosion during the rise and fall of flood water and, as applicable, wave action.

2. In floodways, unless it has been demonstrated through hydrologic and hydraulic analyses performed by a registered design professional in accordance with standard engineering practice that the proposed grading or fill, or both, will not result in any increase in flood levels during the occurrence of the design flood.

3. In coastal high hazard areas, unless such fill is conducted or placed to avoid diversion of water and waves toward any building or structure.
4. Where design flood elevations are specified but floodways have not been designated, unless it has been demonstrated that the cumulative effect of the proposed flood hazard area encroachment, when combined with all other existing and anticipated flood hazard area encroachment, will not increase the design flood elevation more than 1 foot (305 mm) at any point.

18.4.6 Compacted fill material.
Where shallow foundations will bear on compacted fill material, the compacted fill shall comply with the provisions of an approved geotechnical report, as set forth in Clause 18.3.

Exception: Compacted fill material 12 inches (305 mm) in depth or less need not comply with an approved report, provided that the in-place dry density is not less than 90 percent of the maximum dry density at optimum moisture content determined in accordance with ASTM D1557. The compaction shall be verified by special inspection in accordance with Part 19.5.6.

18.4.7 Selected fill material (SFM).
Where shallow foundations will bear on selected fill material (SFM), the (SFM shall comply with the provisions of an approved geotechnical report, as set forth in Clause 18.3.

18.5 DAMPROOFING AND WATERPROOFING

18.5.1 General.
Walls or portions thereof that retain earth and enclose interior spaces and floors below grade shall be waterproofed and dampproofed in accordance with this clause, with the exception of those spaces containing groups other than residential and institutional where such omission is not detrimental to the building or occupancy.

Ventilation for crawl spaces shall comply with Clause 13.3.4.

18.5.1.1 Storey above grade plane.
Where a basement is considered a storey above grade plane and the finished ground level adjacent to the basement wall is below the basement floor elevation for 25 percent or more of the perimeter, the floor and walls shall be dampproofed in accordance with Clause 18.5.2 and a foundation drain shall be installed in accordance with Clause 18.5.4.2. The foundation drain shall be installed around the portion of the perimeter where the basement floor is below ground level. The provisions of Clauses 18.3.5.4, 18.5.3 and 18.5.4.1 shall not apply in this case.

18.5.1.2 Under-floor space.
The finished ground level of an under-floor space such as a crawl space shall not be located below the bottom of the footings. Where there is evidence that the ground-water table rises to within 152 mm (6 inches) of the ground level at the outside building perimeter, or that the surface water does not readily drain from the building site, the ground level of the under-floor space shall be as high as the outside finished ground level, unless an approved drainage system is provided. The provisions of Clauses 18.3.5.4, 18.5.2, 18.5.3 and 18.5.4 shall not apply in this case.

18.5.1.2.1 Flood hazard areas.
For buildings and structures in flood hazard areas as established in this Code, the finished ground level of an under-floor space such as a crawl space shall be equal to or higher than the outside finished ground level on one side or more.

Exception: Under-floor spaces of Group R-3 buildings that meet the requirements of this Code.
18.5.1.3 Ground-water control.

The design of the system to lower the ground-water table shall be based on accepted principles of engineering that shall consider, but not necessarily be limited to, permeability of the soil, rate at which water enters the drainage system, rated capacity of pumps, head against which pumps are to operate and the rated capacity of the disposal area of the system.

18.5.2 Dampproofing.

Where hydrostatic pressure will not occur as determined by Clause 18.3.5.4, floors and walls for other than wood foundation systems shall be dampproofed in accordance with this clause. Wood foundation systems shall be constructed in accordance with GS 146.

18.5.2.1 Floors.

Dampproofing materials for floors shall be installed between the floor and the base course required by Clause 18.5.4.1, except where a separate floor is provided above a concrete slab.

Where installed beneath the slab, dampproofing shall consist of not less than 6-mil (0.152 mm; 0.006 inch) polyethylene with joints lapped not less than 152 mm (6 inches), or other approved methods or materials. Where permitted to be installed on top of the slab, dampproofing shall consist of mopped-on bitumen, not less than 4-mil (0.102 mm; 0.004 inch) polyethylene, or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer’s installation instructions.

18.5.2.2 Walls.

Dampproofing materials for walls shall be installed on the exterior surface of the wall, and shall extend from the top of the footing to above ground level.

Dampproofing shall consist of a bituminous material, 16 N/m² (3 pounds per square yard) of acrylic modified cement, 3.2 mm (1/8 inch) coat of surface-bonding mortar complying with ASTM C887, any of the materials permitted for waterproofing by Clause 18.5.3.2 or other approved methods or materials.

18.5.2.2.1 Surface preparation of walls.

Prior to application of dampproofing materials on concrete walls, holes and recesses resulting from the removal of form ties shall be sealed with a bituminous material or other approved methods or materials. Unit masonry walls shall be parged on the exterior surface below ground level with not less than 9.5 mm (3/8 inch) of Portland cement mortar. The parging shall be coved at the footing.

Exception: Parging of unit masonry walls is not required where a material is approved for direct application to the masonry.

18.5.3 Waterproofing.

Where the ground-water investigation required by Clause 18.3.5.4 indicates that a hydrostatic pressure condition exists, and the design does not include a ground-water control system as described in Clause 18.5.1.3, walls and floors shall be waterproofed in accordance with this clause.

18.5.3.1 Floors.

Floors required to be waterproofed shall be of concrete and designed and constructed to withstand the hydrostatic pressures to which the floors will be subjected.

Waterproofing shall be accomplished by placing a membrane of rubberized asphalt, butyl rubber, fully adhered/fully bonded HDPE or polyolefin composite membrane or not less than 6-mil [0.006 inch (0.152 mm)] polyvinyl chloride with joints lapped not less than 152 mm (6 inches) or other approved materials under the slab. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer’s installation instructions.
18.5.3.2 Walls.

Walls required to be waterproofed shall be of concrete or masonry and shall be designed and constructed to withstand the hydrostatic pressures and other lateral loads to which the walls will be subjected.

Waterproofing shall be applied from the bottom of the wall to not less than 305 mm (12 inches) above the maximum elevation of the ground-water table. The remainder of the wall shall be dampproofed in accordance with Clause 18.5.2.2. Waterproofing shall consist of two-ply hot-mopped felts, not less than 6-mil (0.006 inch; 0.152 mm) polyvinyl chloride, 40-mil (0.040 inch; 1.02 mm) polymer-modified asphalt, 6-mil (0.006 inch; 0.152 mm) polyethylene or other approved methods or materials capable of bridging nonstructural cracks. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer’s installation instructions.

18.5.3.2.1 Surface preparation of walls.

Prior to the application of waterproofing materials on concrete or masonry walls, the walls shall be prepared in accordance with Clause 18.5.2.2.1.

18.5.3.3 Joints and penetrations.

Joints in walls and floors, joints between the wall and floor and penetrations of the wall and floor shall be made water tight utilizing approved methods and materials.

18.5.4 Subsoil drainage system.

Where a hydrostatic pressure condition does not exist, dampproofing shall be provided and a base shall be installed under the floor and a drain installed around the foundation perimeter. A subsoil drainage system designed and constructed in accordance with Clause 1805.1.3 shall be deemed adequate for lowering the ground-water table.

18.5.4.1 Floor base course.

Floors of basements, except as provided for in Clause 18.5.1.1, shall be placed over a floor base course not less than 102 mm (4 inches) in thickness that consists of gravel or crushed stone containing not more than 10 percent of material that passes through a No. 4 (4.75 mm) sieve.

Exception: Where a site is located in well-drained gravel or sand/gravel mixture soils, a floor base course is not required.

18.5.4.2 Foundation drain.

A drain shall be placed around the perimeter of a foundation that consists of gravel or crushed stone containing not more than 10 percent material that passes through a No. 4 (4.75 mm) sieve. The drain shall extend not less than 305 mm (12 inches) beyond the outside edge of the footing. The thickness shall be such that the bottom of the drain is not higher than the bottom of the base under the floor, and that the top of the drain is not less than 152 mm (6 inches) above the top of the footing. The top of the drain shall be covered with an approved filter membrane material. Where a drain tile or perforated pipe is used, the invert of the pipe or tile shall not be higher than the floor elevation. The top of joints or the top of perforations shall be protected with an approved filter membrane material. The pipe or tile shall be placed on not less than 51 mm (2 inches) of gravel or crushed stone complying with Clause 18.5.4.1, and shall be covered with not less than 152 mm (6 inches) of the same material.

18.5.4.3 Drainage discharge.

The floor base and foundation perimeter drain shall discharge by gravity or mechanical means into an approved drainage system that complies with this Code.
Exception: Where a site is located in well-drained gravel or sand/gravel mixture soils, a dedicated drainage system is not required.

18.6 PRESUMPTIVE LOAD-BEARING VALUES OF SOILS
(Use limited to Preliminary Designs)

18.6.1 Load combinations.

The presumptive load-bearing values provided in Table 18.6.2 shall be used with the allowable stress design load combinations specified in this Code. The values of vertical foundation pressure and lateral bearing pressure given in Table 18.6.2 shall be permitted to be increased by one-third where used with the alternative basic load combinations of this Code that include wind or earthquake loads.

18.6.2 Presumptive load-bearing values.

The load-bearing values used in design for supporting soils near the surface shall not exceed the values specified in Table 18.6.2 unless data to substantiate the use of higher values are submitted and approved. Where the building official has reason to doubt the classification, strength or compressibility of the soil, the requirements of Clause 18.3.5.2 shall be satisfied.

Presumptive load-bearing values shall apply to materials with similar physical characteristics and dispositions. Mud, organic silt, organic clays, peat or unprepared fill shall not be assumed to have a presumptive load-bearing capacity unless data to substantiate the use of such a value are submitted.

TABLE 18.6.2
PRESUMPTIVE LOAD-BEARING VALUES

<table>
<thead>
<tr>
<th>CLASS OF MATERIALS</th>
<th>VERTICAL FOUNDATION PRESSURE (kN/m²)</th>
<th>LATERAL BEARING PRESSURE (kN/m below natural grade)</th>
<th>LATERAL SLIDING RESISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Crystalline bedrock</td>
<td>574.8</td>
<td>188.4</td>
<td>0.70</td>
</tr>
<tr>
<td>2. Sedimentary and foliated rock</td>
<td>191.6</td>
<td>62.8</td>
<td>0.35</td>
</tr>
<tr>
<td>3. Sandy gravel and gravel (GW and GP)</td>
<td>143.7</td>
<td>31.4</td>
<td>0.35</td>
</tr>
<tr>
<td>4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)</td>
<td>95.8</td>
<td>23.6</td>
<td>0.25</td>
</tr>
<tr>
<td>5. Clay, sandy clay, silty clay, clayey silt,</td>
<td>71.9</td>
<td>15.7</td>
<td>—</td>
</tr>
</tbody>
</table>
silt and sandy silt (CL, ML, MH and CH)

Note:
  a. Coefficient to be multiplied by the dead load.
  b. Cohesion value to be multiplied by the contact area, as limited by Clause 18.6.3.2.

18.6.3 Lateral load resistance.
Where the presumptive values of Table 18.6.2 are used to determine resistance to lateral loads, the calculations shall be in accordance with Clauses 18.6.3.1 through 18.6.3.4.

18.6.3.1 Combined resistance.
The total resistance to lateral loads shall be permitted to be determined by combining the values derived from the lateral bearing pressure and the lateral sliding resistance specified in Table 18.6.2.

18.6.3.2 Lateral sliding resistance limit.
For clay, sandy clay, silty clay, clayey silt, silt and sandy silt, the lateral sliding resistance shall not exceed one-half the dead load.

18.6.3.3 Increase for depth.
The lateral bearing pressures specified in Table 18.6.2 shall be permitted to be increased by the tabular value for each additional foot (305 mm) of depth to a value that is not greater than 15 times the tabular value.

18.6.3.4 Increase for poles.
Isolated poles for uses such as flagpoles or signs and poles used to support buildings that are not adversely affected by a 12.7 mm (1/2-inch) motion at the ground surface due to short-term lateral loads shall be permitted to be designed using lateral bearing pressures equal to two times the tabular values.

18.7 FOUNDATION WALLS, RETAINING WALLS AND EMBEDDED POSTS AND POLES

18.7.1 Foundation walls.
Foundation walls shall be designed and constructed in accordance with Clauses 18.7.1.1 through 18.7.1.6. Foundation walls shall be supported by foundations designed in accordance with Clause 18.8.

18.7.1.1 Design lateral soil loads.
Foundation walls shall be designed for the lateral soil loads set forth in this Code.

18.7.1.2 Unbalanced backfill height.
Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab on grade is provided and is in contact with the interior surface of the foundation wall, the unbalanced backfill height shall be permitted to be measured from the exterior finish ground level to the top of the interior concrete slab.

18.7.1.3 Rubble stone foundation walls.
Foundation walls of rough or random rubble stone shall be not less than 406 mm (16 inches) thick. Rubble stone shall not be used for foundation walls of structures assigned to Seismic Design Category C, D, E or F.
18.7.1.4 Permanent wood foundation systems.

Permanent wood foundation systems shall be designed and installed in accordance with this Code. Timber and plywood shall be preservative treated in accordance with (Commodity Specification A, Special Requirement 4.2) and shall be identified in accordance with Clause 24.3.1.9.1.

18.7.1.5 Concrete and masonry foundation walls.

Concrete and masonry foundation walls shall be designed in accordance with Part 20 or 22, as applicable.

Exception: Concrete and masonry foundation walls shall be permitted to be designed and constructed in accordance with Clause 18.7.1.6.

18.7.1.6 Prescriptive design of concrete and masonry foundation walls.

Concrete and masonry foundation walls that are laterally supported at the top and bottom shall be permitted to be designed and constructed in accordance with this clause.

18.7.1.6.1 Foundation wall thickness.

The thickness of prescriptively designed foundation walls shall be not less than the thickness of the wall supported, except that foundation walls of not less than 203 mm (8-inch) nominal width shall be permitted to support brick-veneer frame walls and 254 mm (10-inch-wide) cavity walls provided that the requirements of Clause 18.7.1.6.2 or 18.7.1.6.3 are met.

18.7.1.6.2 Concrete foundation walls.

Concrete foundation walls shall comply with the following:

1. The thickness shall comply with the requirements of Table 18.7.1.6.2.

2. The size and spacing of vertical reinforcement shown in Table 1807.1.6.2 are based on the use of reinforcement with a minimum yield strength of 414 MPa (60,000 pounds per square inch (psi)). Vertical reinforcement with a minimum yield strength of 40,000 psi (276 MPa) or 345 MPa (50,000 psi) shall be permitted, provided that the same size bar is used and the spacing shown in the table is reduced by multiplying the spacing by 0.67 or 0.83, respectively.

3. Vertical reinforcement, where required, shall be placed nearest the inside face of the wall a distance, d, from the outside face (soil face) of the wall. The distance, d, is equal to the wall thickness, t, minus 1.25 inches (32 mm) plus one-half the bar diameter, db, [d = t - (1.25 + db / 2)]. The reinforcement shall be placed within a tolerance of ± 3/8 inch (9.5 mm) where d is less than or equal to 203 mm (8 inches) or ± 1/2 inch (12.7 mm) where d is greater than 203 mm (8 inches).

4. In lieu of the reinforcement shown in Table 18.7.1.6.2, smaller reinforcing bar sizes with closer spacings that provide an equivalent cross-clauseal area of reinforcement per unit length shall be permitted.

5. Concrete cover for reinforcement measured from the inside face of the wall shall be not less than 19.1 mm (3/4 inch). Concrete cover for reinforcement measured from the outside face of the wall shall be not less than 38 mm (11/2 inches) for No. 5 bars and smaller, and not less than 51 mm (2 inches) for larger bars.

6. Concrete shall have a specified compressive strength, f 'c, of not less than 17.2 MPa (2,500 psi).

7. The unfactored axial load per linear foot of wall shall not exceed 1.2 t f 'c where t is the specified wall thickness in inches.
### TABLE 1807.1.6.2
CONCRETE FOUNDATION WALLS b, c

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT* (feet)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
<th>30°</th>
<th>45°</th>
<th>60°</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design lateral soil load* (psf per foot of depth)</td>
<td>7.5</td>
<td>9.5</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum wall thickness (inches)</td>
<td>7.5</td>
<td>9.5</td>
<td>11.5</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
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<tr>
<td></td>
<td>5</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
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<tr>
<td></td>
<td>5</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
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<tr>
<td></td>
<td>5</td>
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<td>6</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>#5 at 46</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>#5 at 47</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
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<tr>
<td></td>
<td>5</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
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<td>6</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>#5 at 47</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
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<tr>
<td></td>
<td>6</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>#5 at 47</td>
<td>PC</td>
<td>PC</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#5 at 41</td>
<td>#6 at 43</td>
<td>#6 at 43</td>
<td>PC</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

a. For design lateral soil loads, see part 17

b. Provisions for this table are based on design and construction requirements specified in Clause 18.7.1.6.2.

c. PC = Plain Concrete.

d. Where unbalanced backfill height exceeds 8 feet and design lateral soil loads from this Code are used, the requirements for 30 and 45 psf per foot of depth are not applicable.

e. For height of unbalanced backfill, see Clause 18.7.1.2.

#### 18.7.1.6.2.1 Seismic requirements.

Based on the seismic design category assigned to the structure in accordance with this Code concrete foundation walls designed using Table 18.7.1.6.2 shall be subject to the following limitations:

1. Seismic Design Categories A and B. Not less than one No. 5 bar shall be provided around window, door and similar sized openings. The bar shall be anchored to develop fy in tension at the corners of openings.

2. Seismic Design Categories C, D, E and F. Tables shall not be used except as allowed for plain concrete members in Clause 20.5.1.7.

#### 18.7.1.6.3 Masonry foundation walls.

Masonry foundation walls shall comply with the following:

1. The thickness shall comply with the requirements of Table 18.7.1.6.3(1) for plain masonry walls or Table 18.7.1.6.3(2), 18.7.1.6.3(3) or 18.7.1.6.3(4) for masonry walls with reinforcement.

2. Vertical reinforcement shall have a minimum yield strength of 414 MPa (60,000 psi).
3. The specified location of the reinforcement shall equal or exceed the effective depth distance, d, noted in Tables 18.7.1.6.3(2), 18.7.1.6.3(3) and 18.7.1.6.3(4) and shall be measured from the face of the exterior (soil) side of the wall to the center of the vertical reinforcement. The reinforcement shall be placed within the tolerances specified in TMS 602, Article 3.4.B.11, of the specified location.

4. Grout shall comply with Clause 22.3.3.

5. Concrete masonry units shall comply with ASTM C90.

6. Clay masonry units shall comply with ASTM C652 for hollow brick, except compliance with ASTM C62 or ASTM C216 shall be permitted where solid masonry units are installed in accordance with Table 18.7.1.6.3(1) for plain masonry.

7. Masonry units shall be laid in running bond and installed with Type M or S mortar in accordance with Clause 22.3.2.1.

8. The unfactored axial load per linear foot of wall shall not exceed 1.2 \( t \cdot f' \) where \( t \) is the specified wall thickness in inches and \( f' \) is the specified compressive strength of masonry in pounds per square inch.

9. Not less than 102 mm (4 inches) of solid masonry shall be provided at girder supports at the top of hollow masonry unit foundation walls.

10. Corbeling of masonry shall be in accordance with Clause 22.4.1. Where an 203 mm (8-inch) wall is corbeled, the top corbel shall not extend higher than the bottom of the floor framing and shall be a full course of headers not less than 152 mm (6 inches) in length or the top course bed joint shall be tied to the vertical wall projection. The tie shall be W2.8 (4.8 mm) and spaced at a maximum horizontal distance of 914 mm (36 inches). The hollow space behind the corbelled masonry shall be filled with mortar or grout.

### TABLE 18.7.1.6.3(1)  
**PLAIN MASONRY FOUNDATION WALLS** a, b, c

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet)</th>
<th>MINIMUM NOMINAL WALL THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design lateral soil load ( a ) (psf per foot of depth)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 ( f )</td>
</tr>
<tr>
<td>7</td>
<td>4 (or less)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>4 (or less)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>10 (solid ( c ))</td>
</tr>
<tr>
<td>9</td>
<td>4 (or less)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

Note: The use of solid masonry units in the corbelled section shall be limited to weights not less than 39.8 pounds per cubic foot.
TABLE 18.7.1.6.3(2)
8-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE d ≥ 5 INCHES a,b,c

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet-inches)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT d (feet-inches)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
<th>Design lateral soil load a (psf per foot of depth)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30 e</td>
<td>45 e</td>
</tr>
<tr>
<td>7-4</td>
<td>4-0 (or less)</td>
<td>#4 at 48</td>
<td>#4 at 48</td>
</tr>
<tr>
<td></td>
<td>5-0</td>
<td>#4 at 48</td>
<td>#5 at 48</td>
</tr>
<tr>
<td></td>
<td>6-0</td>
<td>#5 at 48</td>
<td>#6 at 48</td>
</tr>
<tr>
<td></td>
<td>7-4</td>
<td>#6 at 48</td>
<td>#7 at 48</td>
</tr>
<tr>
<td>8-0</td>
<td>4-0 (or less)</td>
<td>#4 at 48</td>
<td>#4 at 48</td>
</tr>
<tr>
<td></td>
<td>5-0</td>
<td>#4 at 48</td>
<td>#5 at 48</td>
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<tr>
<td></td>
<td>6-0</td>
<td>#5 at 48</td>
<td>#6 at 48</td>
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<tr>
<td></td>
<td>7-0</td>
<td>#5 at 48</td>
<td>#6 at 48</td>
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<tr>
<td></td>
<td>8-0</td>
<td>#5 at 48</td>
<td>#6 at 48</td>
</tr>
<tr>
<td>8-8</td>
<td>4-0 (or less)</td>
<td>#4 at 48</td>
<td>#4 at 48</td>
</tr>
<tr>
<td></td>
<td>5-0</td>
<td>#4 at 48</td>
<td>#5 at 48</td>
</tr>
<tr>
<td></td>
<td>6-0</td>
<td>#4 at 48</td>
<td>#5 at 48</td>
</tr>
<tr>
<td></td>
<td>7-0</td>
<td>#5 at 48</td>
<td>#6 at 48</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

a. For design lateral soil loads, see Part 17.
b. Provisions for this table are based on design and construction requirements specified in Clause 18.7.1.6.3.
c. Solid grouted hollow units or solid masonry units.
d. A design in compliance with Part 21 or reinforcement in accordance with Table 18.7.1.6.3(2) is required.
e. For height of unbalanced backfill, see Clause 18.7.1.2.
f. Where unbalanced backfill height exceeds 8 feet and design lateral soil loads from Table 1610.1 are used, the requirements for 30 and 45 psf per foot of depth are not applicable.
### TABLE 18.7.1.6.3(3)
10-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE \( d \leq 6.75 \) INCHES \(^{a,b,c}\)

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet-inches)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT (feet-inches)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design lateral soil load (^{a}) (psf per foot of depth)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30  (^{e})</td>
</tr>
<tr>
<td>7-4</td>
<td>4-0 (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5-0</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>6-0</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>7-4</td>
<td>#4 at 56</td>
</tr>
<tr>
<td>8-0</td>
<td>4-0 (or less)</td>
<td>#4 at 56</td>
</tr>
<tr>
<td></td>
<td>5-0</td>
<td>#4 at 56</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.

**a.** For design lateral soil loads, see Part 17.

**b.** Provisions for this table are based on design and construction requirements specified in Clause 18.7.1.6.3.

**c.** For alternative reinforcement, see Clause 18.7.1.6.3.1.

**d.** For height of unbalanced backfill, see Clause 18.7.1.2.

**e.** Where unbalanced backfill height exceeds 8 feet and design lateral soil loads from this Code are used, the requirements for 30 and 45 psf per foot of depth are not applicable.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 1.157 kPa/m.

a. For design lateral soil loads, See Part 17
b. Provisions for this table are based on design and construction requirements specified in Clause 18.7.1.6.3.
c. For alternative reinforcement, see Clause 18.7.1.6.3.1.
d. For height of unbalanced backfill, see Clause 18.7.1.2.
e. Where unbalanced backfill height exceeds 8 feet and design lateral soil loads from this Code are used, the requirements for 30 and 45 psf per foot of depth are not applicable.

### TABLE 18.7.1.6.3(4)
12-INCH MASONRY FOUNDATION WALLS WITH REINFORCEMENT WHERE d < 8.75 INCHES

<table>
<thead>
<tr>
<th>MAXIMUM WALL HEIGHT (feet-inches)</th>
<th>MAXIMUM UNBALANCED BACKFILL HEIGHT d (feet-inches)</th>
<th>MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-0 (or less)</td>
<td>#4 at 56</td>
<td>30 e</td>
</tr>
<tr>
<td>5-0</td>
<td>#4 at 56</td>
<td>45 e</td>
</tr>
<tr>
<td>6-0</td>
<td>#4 at 56</td>
<td>60 e</td>
</tr>
<tr>
<td>7-0</td>
<td>#4 at 56</td>
<td>30 e</td>
</tr>
<tr>
<td>8-0</td>
<td>#4 at 56</td>
<td>45 e</td>
</tr>
<tr>
<td>9-4</td>
<td>#4 at 56</td>
<td>60 e</td>
</tr>
<tr>
<td>10-0</td>
<td>#4 at 56</td>
<td>30 e</td>
</tr>
<tr>
<td>12-0</td>
<td>#4 at 56</td>
<td>45 e</td>
</tr>
</tbody>
</table>

For design lateral soil loads, See Part 17
a. Provisions for this table are based on design and construction requirements specified in Clause 18.7.1.6.3.
b. For alternative reinforcement, see Clause 18.7.1.6.3.1.
c. For height of unbalanced backfill, see Clause 18.7.1.2.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 1.157 kPa/m.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot per foot = 0.157 kPa/m.
a. For design lateral soil loads.
b. Provisions for this table are based on design and construction requirements specified in Clause 18.7.1.6.3.
c. For alternative reinforcement, see Clause 18.7.1.6.3.1.
d. For height of unbalanced backfill, see Clause 18.7.1.2.
e. Where unbalanced backfill height exceeds 8 feet and design lateral soil loads from this Code are used, the requirements for 30 and 45 psf per foot of depth are not applicable.

### 18.7.1.6.3.1 Alternative foundation wall reinforcement.

In lieu of the reinforcement provisions for masonry foundation walls in Table 18.7.1.6.3(2), 18.7.1.6.3(3) or 18.7.1.6.3(4), alternative reinforcing bar sizes and spacings having an equivalent cross-clauseal area of reinforcement per linear foot (mm) of wall shall be permitted to be used, provided that the spacing of reinforcement does not exceed 1829 mm (72 inches) and reinforcing bar sizes do not exceed No. 11.

### 18.7.1.6.3.2 Seismic requirements.

Based on the seismic design category assigned to the structure in accordance with this Code, masonry foundation walls designed using Tables 18.7.1.6.3(1) through 18.7.1.6.3(4) shall be subject to the following limitations:

1. Seismic Design Categories A and B. No additional seismic requirements.

2. Seismic Design Category C. A design using Tables 18.7.1.6.3(1) through 18.7.1.6.3(4) is subject to the seismic requirements of Clause 7.4.3 of TMS 402.

3. Seismic Design Category D. A design using Tables 18.7.1.6.3(2) through 18.7.1.6.3(4) is subject to the seismic requirements of Clause 7.4.4 of TMS 402.

4. Seismic Design Categories E and F. A design using Tables 18.7.1.6.3(2) through 18.7.1.6.3(4) is subject to the seismic requirements of Clause 7.4.5 of TMS 402.

### 18.7.2 Retaining walls.

Retaining walls shall be designed in accordance with Clauses 18.7.2.1 through 18.7.2.3.
18.7.2.1 General.

Retaining walls shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift.

18.7.2.2 Design lateral soil loads.

Retaining walls shall be designed for the lateral soil loads set forth in Clause 1610. For structures assigned to Seismic Design Category D, E, or F, the design of retaining walls supporting more than 1829 mm (6 feet) of backfill height shall incorporate the additional seismic lateral earth pressure in accordance with the geotechnical investigation where required in Clause 18.3.2.

18.7.2.3 Safety factor.

Retaining walls shall be designed to resist the lateral action of soil to produce sliding and overturning with a minimum safety factor of 1.5 in each case. The load combinations of this Code shall not apply to this requirement. Instead, design shall be based on 0.7 times nominal earthquake loads, 1.0 times other nominal loads, and investigation with one or more of the variable loads set to zero. The safety factor against lateral sliding shall be taken as the available soil resistance at the base of the retaining wall foundation divided by the net lateral force applied to the retaining wall.

Exception: Where earthquake loads are included, the minimum safety factor for retaining wall sliding and overturning shall be 1.1.

18.7.3 Embedded posts and poles.

Designs to resist both axial and lateral loads employing posts or poles as columns embedded in earth or in concrete footings in earth shall be in accordance with Clauses 18.7.3.1 through 18.7.3.3.

18.7.3.1 Limitations.

The design procedures outlined in this clause are subject to the following limitations:

1. The frictional resistance for structural walls and slabs on silts and clays shall be limited to one-half of the normal force imposed on the soil by the weight of the footing or slab.

2. Posts embedded in earth shall not be used to provide lateral support for structural or nonstructural materials such as plaster, masonry or concrete unless bracing is provided that develops the limited deflection required.

Wood poles shall be treated in accordance with AWPA U1 for sawn timber posts (Commodity Specification A, Use Category 4B) and for round timber posts (Commodity Specification B, Use Category 4B).

18.7.3.2 Design criteria.

The depth to resist lateral loads shall be determined using the design criteria established in Clauses 18.7.3.2.1 through 18.7.3.2.3, or by other methods approved by the building official.

18.7.3.2.1 Nonconstrained.

The following formula shall be used in determining the depth of embedment required to resist lateral loads where lateral constraint is not provided at the ground surface, such as by a rigid floor or rigid ground surface pavement, and where lateral constraint is not provided above the ground surface, such as by a structural diaphragm.

\[
d = 0.5A\left(1 + \left[1 + (4.36hlA)^{1/2}\right]\right)
\]

Where:

\[
\begin{align*}
A &= 2.34P/(S_1b) \\
b &= \text{Diameter of round post or footing or diagonal dimension of square post or footing, feet (m).} \\
d &= \text{Depth of embedment in earth in feet (m) for purpose of computing lateral pressure.} \\
h &= \text{Distance in feet (m) from ground surface to point of application of } P. \\
P &= \text{Applied lateral force in pounds (kN).} \\
S_1 &= \text{Allowable lateral soil-bearing pressure as set forth in Clause 1806.2 based on a depth of onethird the depth of embedment.}
\end{align*}
\]
18.7.3.2.2 Constrained.

The following formula shall be used to determine the depth of embedment required to resist lateral loads where lateral constraint is provided at the ground surface, such as by a rigid floor or pavement.

\[ d = \sqrt[3]{\frac{4.25Ph}{S_3b}} \]  
(Equation 18-2)

Or alternatively

\[ d = \sqrt[3]{\frac{4.25M_g}{S_3b}} \]  
(Equation 18-3)

Where:

- \( M_g \) = Moment in the post at grade, in foot-pounds (kN-m).
- \( S_3 \) = Allowable lateral soil-bearing pressure as set forth in Clause 1806.2 based on a depth equal to the depth of embedment in pounds per square foot (kPa).

18.7.3.2.3 Vertical load.

The resistance to vertical loads shall be determined using the vertical foundation pressure set forth in Table 1806.2.

18.7.3.3 Backfill.

The backfill in the annular space around columns not embedded in poured footings shall be by one of the following methods:

1. Backfill shall be of concrete with a specified compressive strength of not less than 13.8 MPa (2,000 psi). The hole shall be not less than 102 mm (4 inches) larger than the diameter of the column at its bottom or 102 mm (4 inches) larger than the diagonal dimension of a square or rectangular column.

2. Backfill shall be of clean sand. The sand shall be thoroughly compacted by tamping in layers not more than 203 mm (8 inches) in depth.

3. Backfill shall be of selected fill material (SFM).

18.8 FOUNDATIONS

18.8.1 General.

Foundations shall be designed and constructed in accordance with Clauses 18.8.2 through 1808.9. Shallow foundations shall satisfy the requirements of Clause 18.9. Deep foundations shall satisfy the requirements of Clause 18.10.

18.8.2 Design for capacity and settlement.

Foundations shall be so designed that the allowable bearing capacity of the soil is not exceeded, and that differential settlement is prevented. Foundations in areas with expansive soils shall be designed in accordance with the provisions of Clause 18.8.6.

18.8.3 Design loads.

Foundations shall be designed for the most unfavorable effects due to the combinations of loads specified in this Code. The dead load is permitted to include the weight of foundations and overlying fill. Reduced live loads, as specified in this Code shall be permitted to be used in the design of foundations.

18.8.3.1 Seismic overturning.

Where foundations are proportioned using the load combinations of this Code and the computation of seismic overturning effects is by equivalent lateral force analysis or modal analysis, the proportioning shall be in accordance with Clause 12.13.4 of ASCE 7.

18.8.3.2 Surcharge.

Fill or other surcharge loads shall not be placed adjacent to any building or structure unless such
building or structure is capable of withstanding the additional loads caused by the fill or the surcharge. Existing footings or foundations that will be affected by any excavation shall be underpinned or otherwise protected against settlement and shall be protected against detrimental lateral or vertical movement or both.

**Exception:** Minor grading for landscaping purposes shall be permitted where done with walk-behind equipment, where the grade is not increased more than 305 mm (1 foot) from original design grade or where approved by the building official.

### 18.8.4 Vibratory loads.

Where machinery operations or other vibrations are transmitted through the foundation, consideration shall be given in the foundation design to prevent detrimental disturbances of the soil.

### 18.8.5 Shifting or moving soils.

Where it is known that the shallow subsoils are of a shifting or moving character, foundations shall be carried to a sufficient depth to ensure stability.

### 18.8.6 Design for expansive soils.

Foundations for buildings and structures founded on expansive soils shall be designed in accordance with Clause 18.8.6.1 or 18.8.6.2.

**Exception:** Foundation design need not comply with Clause 18.8.6.1 or 18.8.6.2 where one of the following conditions is satisfied:

1. The soil is removed in accordance with Clause 18.8.6.3.
2. The building official approves stabilization of the soil in accordance with Clause 18.8.6.4.

### 18.8.6.1 Foundations.

Foundations placed on or within the active zone of expansive soils shall be designed to resist differential volume changes and to prevent structural damage to the supported structure. Deflection and racking of the supported structure shall be limited to that which will not interfere with the usability and serviceability of the structure.

Foundations placed below where volume change occurs or below expansive soil shall comply with the following provisions:

1. Foundations extending into or penetrating expansive soils shall be designed to prevent uplift of the supported structure.
2. Foundations penetrating expansive soils shall be designed to resist forces exerted on the foundation due to soil volume changes or shall be isolated from the expansive soil.

### 18.8.6.2 Slab-on-ground foundations.

Moments, shears and deflections for use in designing slab-on-ground, mat or raft foundations on expansive soils shall be determined in accordance with WRI/CRSI Design of Slab-on-Ground Foundations or PTI DC 10.5. Using the moments, shears and deflections determined above, nonprestressed slabs-on-ground, mat or raft foundations on expansive soils shall be designed in accordance with WRI/CRSI Design of Slab-on-Ground Foundations and post-tensioned slab-on-ground, mat or raft foundations on expansive soils shall be designed in accordance with PTI DC 10.5. It shall be permitted to analyze and design such slabs by other methods that account for soil-structure interaction, the deformed shape of the soil support, the plate or stiffened plate action of the slab as well as both center lift and edge lift conditions. Such alternative methods shall be rational and the basis for all aspects and parameters of the method shall be available for peer review.
18.8.6.3 Removal of expansive soil.

Where expansive soil is removed in lieu of designing foundations in accordance with Clause 18.8.6.1 or 18.8.6.2, the soil shall be removed to a depth sufficient to ensure a constant moisture content in the remaining soil. Fill material shall not contain expansive soils and shall comply with Clause 18.4.5 or 18.4.6.

Exception: Expansive soil need not be removed to the depth of constant moisture, provided that the confining pressure in the expansive soil created by the fill and supported structure exceeds the swell pressure.

18.8.6.4 Stabilization.

Where the active zone of expansive soils is stabilized in lieu of designing foundations in accordance with Clause 18.8.6.1 or 18.8.6.2, the soil shall be stabilized by chemical, dewatering, presaturation or equivalent techniques.

18.8.7 Foundations on or adjacent to slopes.

The placement of buildings and structures on or adjacent to slopes steeper than one unit vertical in three units horizontal (33.3-percent slope) shall comply with Clauses 18.8.7.1 through 18.8.7.5.

18.8.7.1 Building clearance from ascending slopes.

In general, buildings below slopes shall be set a sufficient distance from the slope to provide protection from slope drainage, erosion and shallow failures. Except as provided in Clause 18.8.7.5 and Figure 18.8.7.1, the following criteria will be assumed to provide this protection. Where the existing slope is steeper than one unit vertical in one unit horizontal (100-percent slope), the toe of the slope shall be assumed to be at the intercalce of a horizontal plane drawn from the top of the foundation and a plane drawn tangent to the slope at an angle of 45 degrees (0.79 rad) to the horizontal. Where a retaining wall is constructed at the toe of the slope, the height of the slope shall be measured from the top of the wall to the top of the slope.

![Figure 18.8.7.1: Foundation Clearances from Slopes](image)

For SI: 1 foot = 304.8 mm.

18.8.7.2 Foundation setback from descending slope surface.

Foundations on or adjacent to slope surfaces shall be founded in firm material with an embedment and set back from the slope surface sufficient to provide vertical and lateral support for the foundation without detrimental settlement. Except as provided for in Clause 18.8.7.5 and Figure 18.8.7.1, the following setback is deemed adequate to meet the criteria. Where the slope is steeper than 1 unit vertical in 1 unit horizontal (100-percent slope), the required setback shall be measured from an imaginary plane 45 degrees (0.79 rad) to the horizontal, projected upward from the toe of the slope.

18.8.7.3 Pools.

The setback between pools regulated by this Code and slopes shall be equal to one-half the building footing setback distance required by this clause. That portion of the pool wall within a horizontal distance of 2134 mm (7 feet) from the top of the slope shall be capable of supporting the water in the pool without soil support.

18.8.7.4 Foundation elevation.

On graded sites, the top of any exterior foundation shall extend above the elevation of
the street gutter at point of discharge or the inlet
of an approved drainage device not less than
305 mm (12 inches) plus 2 percent. Alternate
elevations are permitted subject to the approval
of the building official, provided that it can be
demonstrated that required drainage to the point
of discharge and away from the structure is
provided at all locations on the site.

18.8.7.5 Alternate setback and clearance.

Alternate setbacks and clearances are
permitted, subject to the approval of the building
official. The building official shall be permitted to
require a geotechnical investigation as set forth
in Clause 18.3.5.10.

18.8.8 Concrete foundations.

The design, materials and construction of
cement foundations shall comply with Clauses
18.8.8.1 through 18.8.8.6 and the provisions of
Part 20.

Exception: Where concrete footings supporting
walls of light-frame construction are designed in
accordance with Table 18.9.7, a specific design
in accordance with Part 19 is not required.

18.8.8.1 Concrete or grout strength and mix
proportioning.

Concrete or grout in foundations shall have a
specified compressive strength (\( f'c \)) not less
than the largest applicable value indicated in
Table 18.8.8.1.

Where concrete is placed through a funnel
hopper at the top of a deep foundation element,
the concrete mix shall be designed and
proportioned so as to produce a cohesive
workable mix having a slump of not less than 4
inches (102 mm) and not more than 204 mm (8
inches). Where concrete or grout is to be
pumped, the mix design including slump shall be
adjusted to produce a pumpable mixture.

<table>
<thead>
<tr>
<th>TABLE 18.8.8.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINIMUM SPECIFIED COMPRESSIVE STRENGTH ( f'c ) OF CONCRETE OR GROUT</td>
</tr>
<tr>
<td>FOUNDATION ELEMENT OR CONDITION</td>
</tr>
<tr>
<td>1. Foundations for structures assigned to Seismic Design Category A, B or C</td>
</tr>
<tr>
<td>2a. Foundations for Group R or U occupancies of light-frame construction, two stories or less in height, assigned to Seismic Design Category D, E or F</td>
</tr>
<tr>
<td>2b. Foundations for other structures assigned to Seismic Design Category D, E or F</td>
</tr>
<tr>
<td>3. Precast nonprestressed driven piles</td>
</tr>
<tr>
<td>4. Socketed drilled shafts</td>
</tr>
<tr>
<td>5. Micropiles</td>
</tr>
<tr>
<td>6. Precast prestressed driven piles</td>
</tr>
</tbody>
</table>

For SI: 1 pound per square inch = 0.00689 MPa.

<table>
<thead>
<tr>
<th>TABLE 18.8.8.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINIMUM CONCRETE COVER</td>
</tr>
<tr>
<td>FOUNDATION ELEMENT OR CONDITION</td>
</tr>
<tr>
<td>1. Shallow foundations</td>
</tr>
<tr>
<td>2. Precast nonprestressed deep foundation elements Exposed to seawater</td>
</tr>
<tr>
<td>Not manufactured under plant conditions</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Manufactured under plant control conditions</td>
</tr>
</tbody>
</table>

3. Precast prestressed deep foundation elements
   - Exposed to seawater: 2.5 inches
   - Other: In accordance with Clause 20.6.1.3.3 of ACI 318

4. Cast-in-place deep foundation elements not enclosed by a steel pipe, tube or permanent casing: 2.5 inches

5. Cast-in-place deep foundation elements enclosed by a steel pipe, tube or permanent casing: 1 inch

6. Structural steel core within a steel pipe, tube or permanent casing: 2 inches

7. Cast-in-place drilled shafts enclosed by a stable rock socket: 1.5 inches

For SI: 1 inch = 25.4 mm.

18.8.8.2 Concrete cover.

The concrete cover provided for prestressed and nonprestressed reinforcement in foundations shall be not less than the largest applicable value specified in Table 18.8.8.2. Longitudinal bars spaced less than 38 mm (1 1/2 inches) clear distance apart shall be considered to be bundled bars for which the concrete cover provided shall be not less than that required by Clause 20.6.1.3.4 of ACI 318. Concrete cover shall be measured from the concrete surface to the outermost surface of the steel to which the cover requirement applies. Where concrete is placed in a temporary or permanent casing or a mandrel, the inside face of the casing or mandrel shall be considered to be the concrete surface.

18.8.8.3 Placement of concrete.

Concrete shall be placed in such a manner as to ensure the exclusion of any foreign matter and to secure a full-size foundation. Concrete shall not be placed through water unless a tremie or other method approved by the building official is used. Where placed under or in the presence of water, the concrete shall be deposited by approved means to ensure minimum segregation of the mix and negligible turbulence of the water. Where depositing concrete from the top of a deep foundation element, the concrete shall be chuted directly into smooth-sided pipes or tubes or placed in a rapid and continuous operation through a funnel hopper centered at the top of the element.

18.8.8.4 Protection of concrete.

Concrete foundations shall be protected from freezing during depositing and for a period of not less than 5 days thereafter. Water shall not be allowed to flow through the deposited concrete.

18.8.8.5 Forming of concrete.

Concrete foundations are permitted to be cast against the earth where, in the opinion of the building official, soil conditions do not require formwork. Where formwork is required, it shall be in accordance with Clause 26.11 of ACI 318.

18.8.8.6 Seismic requirements.

See Clause 20.5 for additional requirements for foundations of structures assigned to Seismic Design Category C, D, E or F.

For structures assigned to Seismic Design Category D, E or F, provisions of Clause 18.13 of ACI 318 shall apply where not in conflict with the provisions of Clauses 18.8 through 18.10.

Exceptions:

1. Detached one- and two-family dwellings of light-frame construction and two stories or less above grade plane are not required to comply with the provisions of Clause 18.13 of ACI 318.

2. Clause 18.13.4.3(a) of ACI 318 shall not apply.
18.8.9 Vertical masonry foundation elements.
Vertical masonry foundation elements that are not foundation piers as defined in Clause 202 shall be designed as piers, walls or columns, as applicable, in accordance with TMS 402.

18.9 SHALLOW FOUNDATIONS

18.9.1 General.
Shallow foundations shall be designed and constructed in accordance with Clauses 18.9.2 through 18.9.13.

18.9.2 Supporting soils.
Shallow foundations shall be built on undisturbed soil, compacted fill material or selected fill material (SFM). Compacted fill material shall be placed in accordance with Clause 18.4.5. (SFM shall be placed in accordance with Clause 18.4.6.

18.9.3 Stepped footings.
The top surface of footings shall be level. The bottom surface of footings shall be permitted to have a slope not exceeding one unit vertical in 10 units horizontal (10-percent slope). Footings shall be stepped where it is necessary to change the elevation of the top surface of the footing or where the surface of the ground slopes more than one unit vertical in 10 units horizontal (10-percent slope).

18.9.4 Depth and width of footings.
The minimum depth of footings below the undisturbed ground surface shall be 305 mm (12 inches). Where applicable, the requirements of Clause 18.9.5 shall be satisfied. The minimum width of footings shall be 305 mm (12 inches).

18.9.5 Frost protection.
Except where otherwise protected from frost, foundations and other permanent supports of buildings and structures shall be protected from frost by one or more of the following methods:
1. Extending below the frost line of the locality.
2. Constructing in accordance with ASCE 32.
3. Erecting on solid rock.

Exception: Free-standing buildings meeting all of the following conditions shall not be required to be protected:

1. Assigned to Risk Category I.
2. Area of 56 m² (600 square feet) or less for light-frame construction or 37 m² (400 square feet) or less for other than light-frame construction.
3. Eave height of 3048 mm (10 feet) or less.

Shallow foundations shall not bear on frozen soil unless such frozen condition is of a permanent character.

18.9.6 Location of footings.
Footings on granular soil shall be so located that the line drawn between the lower edges of adjoining footings shall not have a slope steeper than 30 degrees (0.52 rad) with the horizontal, unless the material supporting the higher footing is braced or retained or otherwise laterally supported in an approved manner or a greater slope has been properly established by engineering analysis.

18.9.7 Prescriptive footings for light-frame construction.
Where a specific design is not provided, concrete or masonry-unit footings supporting walls of light-frame construction shall be permitted to be designed in accordance with Table 18.9.7.

TABLE 18.9.7
PRESCRIPTIVE FOOTINGS SUPPORTING WALLS OF LIGHT-FRAME CONSTRUCTION

<table>
<thead>
<tr>
<th>NUMBER OF FLOORS SUPPORTED BY THE FOOTING</th>
<th>WIDTH OF FOOTING (inches)</th>
<th>THICKNESS OF FOOTING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>8</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
a. Depth of footings shall be in accordance with Clause 18.9.4.
b. The ground under the floor shall be permitted to be excavated to the elevation of the top of the footing.
c. Interior stud-bearing walls shall be permitted to be supported by isolated footings. The footing width and length shall be twice the width shown in this table, and footings shall be spaced not more than 6 feet on center.
d. See Clause 1905 for additional requirements for concrete footings of structures assigned to Seismic Design Category C, D, E or F.
e. For thickness of foundation walls, see Clause 18.7.1.6.
f. Footings shall be permitted to support a roof in addition to the stipulated number of floors. Footings supporting roof only shall be as required for supporting one floor.
g. Plain concrete footings for Group R-3 occupancies shall be permitted to be 6 inches thick.

18.9.8 Plain concrete footings.

The edge thickness of plain concrete footings supporting walls of other than light-frame construction shall be not less than 203 mm (8 inches) where placed on soil or rock.

Exception: For plain concrete footings supporting Group R-3 occupancies, the edge thickness is permitted to be 152 mm (6 inches), provided that the footing does not extend beyond a distance greater than the thickness of the footing on either side of the supported wall.

18.9.9 Masonry-unit footings.

The design, materials and construction of masonry-unit footings shall comply with Clauses 18.9.9.1 and 18.9.9.2, and the provisions of Part 22.

Exception: Where a specific design is not provided, masonry-unit footings supporting walls of light-frame construction shall be permitted to be designed in accordance with Table 18.9.7.

18.9.9.1 Dimensions.

Masonry-unit footings shall be laid in Type M or S mortar complying with Clause 22.3.2.1 and the depth shall be not less than twice the projection beyond the wall, pier or column. The width shall be not less than 203 mm (8 inches) wider than the wall supported thereon.

18.9.9.2 Offsets.

The maximum offset of each course in brick foundation walls stepped up from the footings shall be 38 mm (1 1/2 inches) where laid in single courses, and 76 mm (3 inches) where laid in double courses.

18.9.10 Pier and curtain wall foundations.

Except in Seismic Design Categories D, E and F, pier and curtain wall foundations shall be permitted to be used to support light-frame construction not more than two stories above grade plane, provided that the following requirements are met:

1. All load-bearing walls shall be placed on continuous concrete footings bonded integrally with the exterior wall footings.
2. The minimum actual thickness of a load-bearing masonry wall shall be not less than 102 mm (4 inches) nominal or 92 mm (35/8 inches) actual thickness, and shall be bonded integrally with piers spaced 1829 mm (6 feet) on center (o.c.).
3. Piers shall be constructed in accordance with Part 22 and the following:
   3.1. The unsupported height of the masonry piers shall not exceed 10 times their least dimension.
   3.2. Where structural clay tile or hollow concrete masonry units are used for piers supporting beams and girders, the
cellular spaces shall be filled solidly with concrete or Type M or S mortar.

1. Exception: Unfilled hollow piers shall be permitted where the unsupported height of the pier is not more than four times its least dimension.

3.3. Hollow piers shall be capped with 102 mm (4 inches) of solid masonry or concrete or the cavities of the top course shall be filled with concrete or grout.

4. The maximum height of a 102 mm (4-inch) load-bearing masonry foundation wall supporting wood frame walls and floors shall not be more than 1219 mm (4 feet) in height.

5. The unbalanced fill for 102 mm (4-inch) foundation walls shall not exceed 610 mm (24 inches) for solid masonry, nor 305 mm (12 inches) for hollow masonry.

18.9.11 Steel grillage footings.
Grillage footings of structural steel elements shall be separated with approved steel spacers and be entirely encased in concrete with not less than 152 mm (6 inches) on the bottom and not less than 102 mm (4 inches) at all other points. The spaces between the shapes shall be completely filled with concrete or cement grout.

18.9.12 Timber footings.
Timber footings shall be permitted for buildings of Type IV construction and as otherwise approved by the building official. Such footings shall be treated in accordance with AWPA U1 (Commodity Specification A, Use Category 4B). Treated timbers are not required where placed entirely below permanent water level, or where used as capping for wood piles that project above the water level over submerged or marsh lands. The compressive stresses perpendicular to grain in untreated timber footings supported on treated piles shall not exceed 70 percent of the allowable stresses for the species and grade of timber as specified in the ANSI/AWC NDS.

18.9.13 Footing seismic ties.
Where a structure is assigned to Seismic Design Category D, E or F, individual spread footings founded on soil defined in Part 20 of ASCE 7 as Site Class E or F shall be interconnected by ties. Unless it is demonstrated that equivalent restraint is provided by reinforced concrete beams within slabs on grade or reinforced concrete slabs on grade, ties shall be capable of carrying, in tension or compression, a force equal to the lesser of the product of the larger footing design gravity load times the seismic coefficient, SDS, divided by 10 and 25 percent of the smaller footing design gravity load.

18.10 DEEP FOUNDATIONS

18.10.1 General.
Deep foundations shall be analyzed, designed, detailed and installed in accordance with Clauses 18.10.1 through 18.10.4.

18.10.1.1 Geotechnical investigation.
Deep foundations shall be designed and installed on the basis of a geotechnical investigation as set forth in Clause 18.3.

18.10.1.2 Use of existing deep foundation elements.
Deep foundation elements left in place where a structure has been demolished shall not be used for the support of new construction unless satisfactory evidence is submitted to the building official, which indicates that the elements are sound and meet the requirements of this Code. Such elements shall be load tested or redriven to verify their capacities. The design load applied to such elements shall be the lowest allowable load as determined by tests or redriving data.

18.10.1.3 Deep foundation elements classified as columns.
Deep foundation elements standing unbraced in air, water or fluid soils shall be classified as
columns and designed as such in accordance with the provisions of this Code from their top down to the point where adequate lateral support is provided in accordance with Clause 18.10.2.1.

Exception: Where the unsupported height to least horizontal dimension of a cast-in-place deep foundation element does not exceed three, it shall be permitted to design and construct such an element as a pedestal in accordance with ACI 318.

18.10.1.4 Special types of deep foundations.

The use of types of deep foundation elements not specifically mentioned herein is permitted, subject to the approval of the building official, upon the submission of acceptable test data, calculations and other information relating to the structural properties and load capacity of such elements. The allowable stresses for materials shall not in any case exceed the limitations specified herein.

18.10.2 Analysis.

The analysis of deep foundations for design shall be in accordance with Clauses 18.10.2.1 through 18.10.2.5.

18.10.2.1 Lateral support.

Any soil other than fluid soil shall be deemed to afford sufficient lateral support to prevent buckling of deep foundation elements and to permit the design of the elements in accordance with accepted engineering practice and the applicable provisions of this Code.

Where deep foundation elements stand unbraced in air, water or fluid soils, it shall be permitted to consider them laterally supported at a point 1524 mm (5 feet) into stiff soil or 3048 mm (10 feet) into soft soil unless otherwise approved by the building official on the basis of a geotechnical investigation by a registered design professional.

18.10.2.2 Stability.

Deep foundation elements shall be braced to provide lateral stability in all directions. Three or more elements connected by a rigid cap shall be considered to be braced, provided that the elements are located in radial directions from the centroid of the group not less than 60 degrees (1 rad) apart. A two-element group in a rigid cap shall be considered to be braced along the axis connecting the two elements. Methods used to brace deep foundation elements shall be subject to the approval of the building official.

Deep foundation elements supporting walls shall be placed alternately in lines spaced not less than 305 mm (1 foot) apart and located symmetrically under the center of gravity of the wall load carried, unless effective measures are taken to provide for eccentricity and lateral forces, or the foundation elements are adequately braced to provide for lateral stability.

Exceptions:

1. Isolated cast-in-place deep foundation elements without lateral bracing shall be permitted where the least horizontal dimension is not less than 610 mm (2 feet), adequate lateral support in accordance with Clause 18.10.2.1 is provided for the entire height and the height does not exceed 12 times the least horizontal dimension.

2. A single row of deep foundation elements without lateral bracing is permitted for one- and two-family dwellings and lightweight construction not exceeding two stories above grade plane or 10 668 mm (35 feet) in building height, provided that the centers of the elements are located within the width of the supported wall.

18.10.2.3 Settlement.

The settlement of a single deep foundation element or group thereof shall be estimated based on approved methods of analysis. The predicted settlement shall cause neither harmful distortion of, nor instability in, the structure, nor cause any element to be loaded beyond its capacity.
18.10.2.4 Lateral loads.

The moments, shears and lateral deflections used for design of deep foundation elements shall be established considering the nonlinear interaction of the shaft and soil, as determined by a registered design professional. Where the ratio of the depth of embedment of the element to its least horizontal dimension is less than or equal to six, it shall be permitted to assume the element is rigid.

18.10.2.4.1 Seismic Design Categories D through F.

For structures assigned to Seismic Design Category D, E or F, deep foundation elements on Site Class E or F sites, as determined in this Code shall be designed and constructed to withstand maximum imposed curvatures from earthquake ground motions and structure response. Curvatures shall include free-field soil strains modified for soil-foundation-structure interaction coupled with foundation element deformations associated with earthquake loads imparted to the foundation by the structure.

Exception: Deep foundation elements that satisfy the following additional detailing requirements shall be deemed to comply with the curvature capacity requirements of this clause.

1. Precast prestressed concrete piles detailed in accordance with Clause 18.10.3.8.3.3.

2. Cast-in-place deep foundation elements with a minimum longitudinal reinforcement ratio of 0.005 extending the full length of the element and detailed in accordance with Clauses 18.7.5.2, 18.7.5.3 and 18.7.5.4 of ACI 318 as required by Clause 18.10.3.9.4.2.2.

18.10.2.5 Group effects.

The analysis shall include group effects on lateral behaviour where the centre-to-centre spacing of deep foundation elements in the direction of lateral force is less than eight times the least horizontal dimension of an element. The analysis shall include group effects on axial behaviour where the centre-to-centre spacing of deep foundation elements is less than three times the least horizontal dimension of an element. Group effects shall be evaluated using a generally accepted method of analysis; the analysis for uplift of grouped elements with centre-to-centre spacing less than three times the least horizontal dimension of an element shall be evaluated in accordance with Clause 18.10.3.3.1.6.

18.10.3 Design and detailing.

Deep foundations shall be designed and detailed in accordance with Clauses 18.10.3.1 through 18.10.3.13.

18.10.3.1 Design conditions.

Design of deep foundations shall include the design conditions specified in Clauses 18.10.3.1.1 through 18.10.3.1.6, as applicable.

18.10.3.1.1 Design methods for concrete elements.

Where concrete deep foundations are laterally supported in accordance with Clause 18.10.2.1 for the entire height and applied forces cause bending moments not greater than those resulting from accidental eccentricities, structural design of the element using the load combinations of this Code and the allowable stresses specified in this part shall be permitted. Otherwise, the structural design of concrete deep foundation elements shall use the load combinations of this Code and approved strength design methods.

18.10.3.1.2 Composite elements.

Where a single deep foundation element comprises two or more clauses of different materials or different types spliced together, each clause of the composite assembly shall satisfy the applicable requirements of this Code, and the maximum allowable load in each clause
shall be limited by the structural capacity of that clause.

18.10.3.1.3 Mislocation.

The foundation or superstructure shall be designed to resist the effects of the mislocation of any deep foundation element by not less than 76 mm (3 inches). To resist the effects of mislocation, compressive overload of deep foundation elements to 110 percent of the allowable design load shall be permitted.

18.10.3.1.4 Driven piles.

Driven piles shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by handling, driving and service loads.

18.10.3.1.5 Helical piles.

Helical piles shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by installation into the ground and service loads.

18.10.3.2 Materials.

The materials used in deep foundation elements shall satisfy the requirements of Clauses 18.10.3.2.1 through 18.10.3.2.8, as applicable.

18.10.3.2.1 Concrete.

Where concrete is cast in a steel pipe or where an enlarged base is formed by compacting concrete, the maximum size for coarse aggregate shall be 19.1 mm (3/4 inch). Concrete to be compacted shall have a zero slump.

18.10.3.2.1.1 Seismic hooks.

For structures assigned to Seismic Design Category C, D, E or F, the ends of hoops, spirals and ties used in concrete deep foundation elements shall be terminated with seismic hooks, as defined in ACI 318, and shall be turned into the confined concrete core.

18.10.3.2.1.2 ACI 318 Equation (25.7.3.3).

Where this part requires detailing of concrete deep foundation elements in accordance with Clause 18.7.5.4 of ACI 318, compliance with Equation (25.7.3.3) of ACI 318 shall not be required.

18.10.3.2.2 Prestressing steel.

Prestressing steel shall conform to ASTM A416.

18.10.3.2.3 Steel.

Structural steel H-piles and structural steel sheet piling shall conform to the material requirements in ASTM A6. Steel pipe piles shall conform to the material requirements in ASTM A252. Fully welded steel piles shall be fabricated from plates that conform to the material requirements in ASTM A36, ASTM A283, ASTM A572, ASTM A588 or ASTM A690.

18.10.3.2.4 Timber.

Timber deep foundation elements shall be designed as piles or poles in accordance with this Code. Round timber elements shall conform to ASTM D25. Sawn timber elements shall conform to DOC PS-20.
18.10.3.2.4.1 Preservative treatment.

Timber deep foundation elements used to support permanent structures shall be treated in accordance with this clause unless it is established that the tops of the untreated timber elements will be below the lowest ground-water level assumed to exist during the life of the structure. Preservative and minimum final retention shall be in accordance with (Commodity Specification E, Use Category 4C) for round timber elements and (Commodity Specification A, Use Category 4B) for sawn timber elements. Preservative-treated timber elements shall be subject to a quality control program administered by an approved agency. Element cutoffs shall be treated in accordance with this Code.

18.10.3.2.5 Protection of materials.

Where boring records or site conditions indicate possible deleterious action on the materials used in deep foundation elements because of soil constituents, changing water levels or other factors, the elements shall be adequately protected by materials, methods or processes approved by the building official. Protective materials shall be applied to the elements so as not to be rendered ineffective by installation. The effectiveness of such protective measures for the particular purpose shall have been thoroughly established by satisfactory service records or other evidence.

18.10.3.2.6 Allowable stresses.

The allowable stresses for materials used in deep foundation elements shall not exceed those specified in Table 18.10.3.2.6.

<table>
<thead>
<tr>
<th>MATERIAL TYPE AND CONDITION</th>
<th>MAXIMUM ALLOWABLE STRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Concrete or grout in compression</td>
<td>0.4 $f'$</td>
</tr>
<tr>
<td>1810.3.2.7 Cast-in-place with a permanent casing in accordance with Clause</td>
<td>$0.33 f'_c$</td>
</tr>
<tr>
<td>Cast-in-place in a pipe, tube, other permanent casing or rock</td>
<td>$0.3 f'_c$</td>
</tr>
<tr>
<td>Cast-in-place without a permanent casing</td>
<td>$0.33 f'_c$</td>
</tr>
<tr>
<td>Precast nonprestressed</td>
<td>$0.33 f'_c$</td>
</tr>
<tr>
<td>Precast prestressed</td>
<td>$0.33 f'_c - 0.27 f_p c$</td>
</tr>
<tr>
<td>2. Nonprestressed reinforcement in compression</td>
<td>$0.4 f \leq 30,000$ psi</td>
</tr>
<tr>
<td>3. Steel in compression</td>
<td>$0.5 F \leq 32,000$ psi</td>
</tr>
<tr>
<td>Cores within concrete-filled pipes or tubes</td>
<td>$0.5 F \leq 32,000$ psi</td>
</tr>
<tr>
<td>Pipes, tubes or H-piles, where justified in accordance with Clause 1810.3.2.8</td>
<td>$0.4 F \leq 32,000$</td>
</tr>
<tr>
<td>Pipes or tubes for micropiles</td>
<td>$0.35 F \leq 16,000$ psi</td>
</tr>
<tr>
<td>Other pipes, tubes or H-piles</td>
<td>$0.6 F \leq 0.5 F_u$</td>
</tr>
<tr>
<td>Helical piles</td>
<td>$0.6 f$</td>
</tr>
<tr>
<td>4. Nonprestressed reinforcement in tension</td>
<td>$0.5 f \leq 24,000$ psi</td>
</tr>
<tr>
<td>Within micropiles</td>
<td>$0.5 f \leq 24,000$ psi</td>
</tr>
</tbody>
</table>
5. Steel in tension
   Pipes, tubes or H-piles, where justified in accordance with Clause 1810.3.2.8
   | 0.5 $F \leq 32,000$ psi
   | 0.35 $F \leq 16,000$ psi
   | 0.6 $F \leq 0.5 \frac{F_u}{F_y}

   Other pipes, tubes or H-piles
   Helical piles
   In accordance with the ANSI/AWC NDS

6. Timber

   a. $f'c$ is the specified compressive strength of the concrete or grout; $f_{pc}$ is the compressive stress on the gross concrete clause due to effective prestress forces; $f_y$ is the specified yield strength of reinforcement; $F_y$ is the specified minimum yield stress of steel; $F_u$ is the specified minimum tensile stress of structural steel.

   b. The stresses specified apply to the gross cross-clauseal area within the concrete surface. Where a temporary or permanent casing is used, the inside face of the casing shall be considered to be the concrete surface.

18.10.3.2.7 Increased allowable compressive stress for cased mandrel-driven cast-in-place elements.

The allowable compressive stress in the concrete shall be permitted to be increased as specified in Table 18.10.3.2.6 for those portions of permanently cased cast-in-place elements that satisfy all of the following conditions:

1. The design shall not use the casing to resist any portion of the axial load imposed.

2. The casing shall have a sealed tip and be mandrel driven.

3. The thickness of the casing shall be not less than manufacturer’s standard gage No.14 (0.068 inch) (1.75 mm).

4. The casing shall be seamless or provided with seams of strength equal to the basic material and be of a configuration that will provide confinement to the cast-in-place concrete.

5. The ratio of steel yield strength ($F_y$) to specified compressive strength ($f'c$) shall be not less than six.

6. The nominal diameter of the element shall not be greater than 406 mm (16 inches).

18.10.3.2.8 Justification of higher allowable stresses.

Use of allowable stresses greater than those specified in Clause 18.10.3.2.6 shall be permitted where supporting data justifying such higher stresses is filed with the building official. Such substantiating data shall include the following:

1. A geotechnical investigation in accordance with Clause 18.3.

2. Load tests in accordance with Clause 18.10.3.3.1.2, regardless of the load supported by the element.

The design and installation of the deep foundation elements shall be under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and deep foundations who shall submit a report to the building official stating that the elements as installed satisfy the design criteria.

18.10.3.3 Determination of allowable loads.

The allowable axial and lateral loads on deep foundation elements shall be determined by an approved formula, load tests or method of analysis.

18.10.3.3.1 Allowable axial load.

The allowable axial load on a deep foundation element shall be determined in accordance with Clauses 18.10.3.3.1.1 through 18.10.3.3.1.9.
18.10.3.3.1 Driving criteria.

The allowable compressive load on any driven deep foundation element where determined by the application of an approved driving formula shall not exceed 356 Kn (40 tons). For allowable loads above 356 Kn (40 tons), the wave equation method of analysis shall be used to estimate driveability for both driving stresses and net displacement per blow at the ultimate load. Allowable loads shall be verified by load tests in accordance with Clause 18.10.3.3.1.2. The formula or wave equation load shall be determined for gravity-drop or power-actuated hammers and the hammer energy used shall be the maximum consistent with the size, strength and weight of the driven elements. The use of a follower is permitted only with the approval of the building official. The introduction of fresh hammer cushion or pile cushion material just prior to final penetration is not permitted.

18.10.3.3.1.2 Load tests.

Where design compressive loads are greater than those determined using the allowable stresses specified in Clause 18.10.3.2.6, where the design load for any deep foundation element is in doubt, or where cast-in-place deep foundation elements have an enlarged base formed either by compacting concrete or by driving a precast base, control test elements shall be tested in accordance with ASTM D1143 or ASTM D4945. One element or more shall be load tested in each area of uniform subsoil conditions. Where required by the building official, additional elements shall be load tested where necessary to establish the safe design capacity. The resulting allowable loads shall not be more than one-half of the ultimate axial load capacity of the test element as assessed by one of the published methods listed in Clause 18.10.3.3.1.3 with consideration for the test type, duration and subsoil. The ultimate axial load capacity shall be determined by a registered design professional with consideration given to tolerable total and differential settlements at design load in accordance with Clause 18.10.2.3. In subsequent installation of the balance of deep foundation elements, all elements shall be deemed to have a supporting capacity equal to that of the control element where such elements are of the same type, size and relative length as the test element; are installed using the same or comparable methods and equipment as the test element; are installed in similar subsoil conditions as the test element; and, for driven elements, where the rate of penetration (for example, net displacement per blow) of such elements is equal to or less than that of the test element driven with the same hammer through a comparable driving distance.

18.10.3.3.1.3 Load test evaluation methods.

It shall be permitted to evaluate load tests of deep foundation elements using any of the following methods:

1. Davisson Offset Limit.

2. Brinch-Hansen 90-percent Criterion.


4. Other methods approved by the building official.

18.10.3.3.1.4 Allowable shaft resistance.

The assumed shaft resistance developed by any uncased cast-in-place deep foundation element shall not exceed one-sixth of the bearing value of the soil material at minimum depth as set forth in Table 18.6.2, up to 500 psf (24 kPa), unless a greater value is allowed by the building official on the basis of a geotechnical investigation as specified in Clause 18.3 or a greater value is substantiated by a load test in accordance with Clause 18.10.3.3.1.2. Shaft resistance and end-bearing resistance shall not be assumed to act simultaneously unless determined by a geotechnical investigation in accordance with Clause 18.3.

18.10.3.3.1.5 Uplift capacity of a single deep foundation element.

Where required by the design, the uplift capacity of a single deep foundation element shall be determined by an approved method of analysis based on a minimum factor of safety of three or by load tests conducted in accordance with
ASTM D3689. The maximum allowable uplift load shall not exceed the ultimate load capacity as determined in Clause 18.10.3.3.1.2, using the results of load tests conducted in accordance with ASTM D3689, divided by a factor of safety of two.

Exception: Where uplift is due to wind or seismic loading, the minimum factor of safety shall be two where capacity is determined by an analysis and one and one-half where capacity is determined by load tests.

18.10.3.3.6 Allowable uplift load of grouped deep foundation elements.

For grouped deep foundation elements subjected to uplift, the allowable uplift load for the group shall be calculated by a generally accepted method of analysis. Where the deep foundation elements in the group are placed at a center-to-center spacing less than three times the least horizontal dimension of the largest single element, the allowable uplift load for the group is permitted to be calculated as the lesser of:

1. The proposed individual allowable uplift load times the number of elements in the group.
2. Two-thirds of the effective weight of the group and the soil contained within a block defined by the perimeter of the group and the length of the element, plus two-thirds of the ultimate shear resistance along the soil block.

18.10.3.3.7 Load-bearing capacity.

Deep foundation elements shall develop ultimate load capacities of not less than twice the design working loads in the designated load-bearing layers. Analysis shall show that soil layers underlyng the designated load-bearing layers do not cause the load-bearing capacity safety factor to be less than two.

18.10.3.3.8 Bent deep foundation elements.

The load-bearing capacity of deep foundation elements discovered to have a sharp or sweeping bend shall be determined by an approved method of analysis or by load testing a representative element.

18.10.3.3.9 Helical piles.

The allowable axial design load, \( P_a \), of helical piles shall be determined as follows:

\[
P_a = 0.5 P_u
\]

(Equation 18-4)

Where \( P_u \) is the least value of:

1. Sum of the areas of the helical bearing plates times the ultimate bearing capacity of the soil or rock comprising the bearing stratum.
2. Ultimate capacity determined from well-documented correlations with installation torque.
3. Ultimate capacity determined from load tests.
4. Ultimate axial capacity of pile shaft.
5. Ultimate axial capacity of pile shaft couplings.
6. Sum of the ultimate axial capacity of helical bearing plates affixed to pile.

18.10.3.3.2 Allowable lateral load.

Where required by the design, the lateral load capacity of a single deep foundation element or a group thereof shall be determined by an approved method of analysis or by lateral load tests to not less than twice the proposed design working load. The resulting allowable load shall not be more than one-half of the load that produces a gross lateral movement of 25 mm (1 inch) at the lower of the top of foundation element and the ground surface, unless it can be shown that the predicted lateral movement shall cause neither harmful distortion of, nor instability in, the structure, nor cause any element to be loaded beyond its capacity.
18.10.3.4 Subsiding soils.
Where deep foundation elements are installed through subsiding fills or other subsiding strata and derive support from underlying firmer materials, consideration shall be given to the downward frictional forces potentially imposed on the elements by the subsiding upper strata.

Where the influence of subsiding fills is considered as imposing loads on the element, the allowable stresses specified in this part shall be permitted to be increased where satisfactory substantiating data are submitted.

18.10.3.5 Dimensions of deep foundation elements.
The dimensions of deep foundation elements shall be in accordance with Clauses 18.10.3.5.1 through 18.10.3.5.3, as applicable.

18.10.3.5.1 Precast.
The minimum lateral dimension of precast concrete deep foundation elements shall be 203 mm (8 inches). Corners of square elements shall be chamfered.

18.10.3.5.2 Cast-in-place or grouted-in-place.
Cast-in-place and grouted-in-place deep foundation elements shall satisfy the requirements of this clause.

18.10.3.5.2.1 Cased.
Cast-in-place or grouted-in-place deep foundation elements with a permanent casing shall have a nominal outside diameter of not less than 203 mm (8 inches).

18.10.3.5.2.2 Uncased.
Cast-in-place or grouted-in-place deep foundation elements without a permanent casing shall have a specified diameter of not less than 305 mm (12 inches). The element length shall not exceed 30 times the specified diameter.

Exception: The length of the element is permitted to exceed 30 times the specified diameter, provided that the design and installation of the deep foundations are under the direct supervision of a registered design professional knowledgeable in the field of soil mechanics and deep foundations. The registered design professional shall submit a report to the building official stating that the elements were installed in compliance with the approved construction documents.

18.10.3.5.2.3 Micropiles.
Micropiles shall have a nominal diameter of 305 mm (12 inches) or less. The minimum diameter set forth elsewhere in Clause 18.10.3.5 shall not apply to micropiles.

18.10.3.5.3 Steel.
Steel deep foundation elements shall satisfy the requirements of this clause.

18.10.3.5.3.1 Structural steel H-piles.
Clauses of structural steel H-piles shall comply with the requirements for HP shapes in ASTM A6, or the following:

1. The flange projections shall not exceed 14 times the minimum thickness of metal in either the flange or the web and the flange widths shall be not less than 80 percent of the depth of the clause.

2. The nominal depth in the direction of the web shall be not less than 8 inches (203 mm).

3. Flanges and web shall have a minimum nominal thickness of 3/8 inch (9.5 mm).

18.10.3.5.3.2 Fully welded steel piles fabricated from plates.

2. Clauses of fully welded steel piles fabricated from plates shall comply with the following:
1. The flange projections shall not exceed 14 times the minimum thickness of metal in either the flange or the web and the flange widths shall be not less than 80 percent of the depth of the clause.

2. The nominal depth in the direction of the web shall be not less than 8 inches (203 mm).

3. Flanges and web shall have a minimum nominal thickness of 3/8 inch (9.5 mm).

18.10.3.5.3.3 Structural steel sheet piling.

Individual clauses of structural steel sheet piling shall conform to the profile indicated by the manufacturer, and shall conform to the general requirements specified by ASTM A6.

18.10.3.5.3.4 Steel pipes and tubes.

Steel pipes and tubes used as deep foundation elements shall have a nominal outside diameter of not less than 203 mm (8 inches). Where steel pipes or tubes are driven open ended, they shall have not less than 219 mm2 (0.34 square inch) of steel in cross clause to resist each 1356 Nm (1,000 foot-pounds) of pile hammer energy, or shall have the equivalent strength for steels having a yield strength greater than 241 MPa (35,000 psi) or the wave equation analysis shall be permitted to be used to assess compression stresses induced by driving to evaluate if the pile clause is appropriate for the selected hammer. Where a pipe or tube with wall thickness less than 4.6 mm (0.179 inch) is driven open ended, a suitable cutting shoe shall be provided. Concrete-filled steel pipes or tubes in structures assigned to Seismic Design Category C, D, E or F shall have a wall thickness of not less than 5 mm (3/16 inch). The pipe or tube casing for socketed drilled shafts shall have a nominal outside diameter of not less than 457 mm (18 inches), a wall thickness of not less than 9.5 mm (3/8 inch) and a suitable steel driving shoe welded to the bottom; the diameter of the rock socket shall be approximately equal to the inside diameter of the casing.

Exceptions:

1. There is no minimum diameter for steel pipes or tubes used in micropiles.

2. For mandrel-driven pipes or tubes, the minimum wall thickness shall be 2.5 mm (1/10 inch).

18.10.3.5.3.5 Helical piles.

Dimensions of the central shaft and the number, size and thickness of helical bearing plates shall be sufficient to support the design loads.

18.10.3.6 Splices.

Splices shall be constructed so as to provide and maintain true alignment and position of the component parts of the deep foundation element during installation and subsequent thereto and shall be designed to resist the axial and shear forces and moments occurring at the location of the splice during driving and for design load combinations. Where deep foundation elements of the same type are being spliced, splices shall develop not less than 50 percent of the bending strength of the weaker clause. Where deep foundation elements of different materials or different types are being spliced, splices shall develop the full compressive strength and not less than 50 percent of the tension and bending strength of the weaker clause. Where structural steel cores are to be spliced, the ends shall be milled or ground to provide full contact and shall be full-depth welded.

Splices occurring in the upper 3048 mm (10 feet) of the embedded portion of an element shall be designed to resist at allowable stresses the moment and shear that would result from an assumed eccentricity of the axial load of 76 mm (3 inches), or the element shall be braced in accordance with Clause 18.10.2.2 to other deep foundation elements that do not have splices in the upper 3048 mm (10 feet) of embedment.

18.10.3.6.1 Seismic Design Categories C through F.

For structures assigned to Seismic Design Category C, D, E or F splices of deep foundation
elements shall develop the lesser of the following:

1. The nominal strength of the deep foundation element.

2. The axial and shear forces and moments from the seismic load effects including overstrength factor in accordance with Clause 2.3.6 or 2.4.5 of ASCE 7.

18.10.3.7 Top of element detailing at cutoffs.

Where a minimum length for reinforcement or the extent of closely spaced confinement reinforcement is specified at the top of a deep foundation element, provisions shall be made so that those specified lengths or extents are maintained after cutoff.

18.10.3.8 Precast concrete piles.

Precast concrete piles shall be designed and detailed in accordance with Clauses 1810.3.8.1 through 1810.3.8.3.

18.10.3.8.1 Reinforcement.

Longitudinal steel shall be arranged in a symmetrical pattern and be laterally tied with steel ties or wire spiral spaced center to center as follows:

1. At not more than 25 mm (1 inch) for the first five ties or spirals at each end; then

2. At not more than 102 mm (4 inches), for the remainder of the first 610 mm (2 feet) from each end; and then

3. At not more than 152 mm (6 inches) elsewhere.

The size of ties and spirals shall be as follows:

1. For piles having a least horizontal dimension of 406 mm (16 inches) or less, wire shall not be smaller than 5.6 mm (0.22 inch) (No. 5 gage).

2. For piles having a least horizontal dimension of more than 406 mm (16 inches) and less than 508 mm (20 inches), wire shall not be smaller than 6 mm (0.238 inch) (No. 4 gage).

3. For piles having a least horizontal dimension of 508 mm (20 inches) and larger, wire shall not be smaller than 6.4 mm (1/4 inch) round or 6.6 mm (0.259 inch) (No. 3 gage).

18.10.3.8.2 Precast nonprestressed piles.

Precast nonprestressed concrete piles shall comply with the requirements of Clauses 18.10.3.8.2.1 through 18.10.3.8.2.3.

18.10.3.8.2.1 Minimum reinforcement.

Longitudinal reinforcement shall consist of not fewer than four bars with a minimum longitudinal reinforcement ratio of 0.008.

18.10.3.8.2.2 Seismic reinforcement in Seismic Design Categories C through F.

For structures assigned to Seismic Design Category C, D, E or F, precast nonprestressed piles shall be reinforced as specified in this clause. The minimum longitudinal reinforcement ratio shall be 0.01 throughout the length. Transverse reinforcement shall consist of closed ties or spirals with a minimum 9.5 mm (3/8 inch) diameter. Spacing of transverse reinforcement shall not exceed the smaller of eight times the diameter of the smallest longitudinal bar or 152 mm (6 inches) within a distance of three times the least pile dimension from the bottom of the pile cap. Spacing of transverse reinforcement shall not exceed 152 mm (6 inches) throughout the remainder of the pile.

18.10.3.8.2.3 Additional seismic reinforcement in Seismic Design Categories D through F.

For structures assigned to Seismic Design Category D, E or F, transverse reinforcement
shall be in accordance with Clause 18.10.3.9.4.2.

18.10.3.8.3 Precast prestressed piles.

Precast prestressed concrete piles shall comply with the requirements of Clauses 18.10.3.8.3.1 through 18.10.3.8.3.3.

18.10.3.8.3.1 Effective prestress.

The effective prestress in the pile shall not be less than 2.76 MPa (400 psi) for piles up to 9144 mm (30 feet) in length, 3.79 MPa (550 psi) for piles up to 240 mm (50 feet) in length and 4.83 MPa (700 psi) for piles greater than 240 mm (50 feet) in length.

Effective prestress shall be based on an assumed loss of 207 MPa (30,000 psi) in the prestressing steel. The tensile stress in the prestressing steel shall not exceed the values specified in ACI 318.

18.10.3.8.3.2 Seismic reinforcement in Seismic Design Category C.

For structures assigned to Seismic Design Category C, precast prestressed piles shall have transverse reinforcement in accordance with the following:

1. Requirements in ACI 318, Part 18, need not apply, unless specifically referenced.

2. Where the total pile length in the soil is 35 feet (10 668 mm) or less, the lateral transverse reinforcement in the ductile region shall occur through the length of the pile. Where the pile length exceeds 35 feet (10 668 mm), the ductile pile region shall be taken as the greater of 35 feet (10 668 mm) or the distance from the underside of the pile cap to the point of zero curvature plus three times the least pile dimension.

3. In the ductile region, the center-to-center spacing of the spirals or hoop reinforcement shall not exceed one-fifth of the least pile dimension, six times the diameter of the longitudinal strand or 8 inches (203 mm), whichever is smallest.

4. Circular spiral reinforcement shall be spliced by lapping one full turn and bending the end of each spiral to a 90-degree hook or by use of a mechanical or welded splice complying with Clause 25.5.7 of ACI 318.

5. Where the transverse reinforcement consists of circular spirals, the volumetric ratio of spiral transverse...
reinforcement in the ductile region shall comply with the following:

\[ \rho_s = 0.06(f', f_c yh)[2.8 + 2.34P/f', A_g] h_c \]

but not exceed:

\[ \rho_s = 0.021 \]  \hspace{1cm} \text{(Equation 18-7)}

Where:

- \( A_g \) = Pile cross-clauseal area, square inches (mm²).
- \( f_c \) = Specified compressive strength of concrete, psi (MPa).
- \( f_yh \) = Yield strength of spiral reinforcement £ 85,000 psi (586 MPa).
- \( P \) = Axial load on pile, pounds (kN), as determined from Equations 16–5 and 16–7.
- \( \rho_s \) = Volumetric ratio (vol. spiral/vol. core).

This required amount of spiral reinforcement is permitted to be obtained by providing an inner and outer spiral.

**Exception:** The minimum spiral reinforcement required by Equation 18–6 shall not apply in cases where the design includes full consideration of load combinations specified in ASCE 7, Clause 2.3.6 and the applicable overstrength factor, \( \Omega_0 \). In such cases, minimum spiral reinforcement shall be as specified in Clause 18.10.3.8.1.

6. Where transverse reinforcement consists of rectangular hoops and cross ties, the total cross-clauseal area of lateral transverse reinforcement in the ductile region with spacing, \( s \), and perpendicular dimension, \( h_c \), shall conform to:

\[ A_{sh} = 0.3s h_c (f'/f_c)(A_g/A_c - 1.0)[0.5 + 1.4P/(f', A_g)] \]

But not less than:

\[ A_{sh} = 0.12s h_c (f'/f_c)[0.5 + 1.4P/(f', A_g)] \]  \hspace{1cm} \text{(Equation 18-8)}

Where:

- \( f' \) = yield strength of transverse reinforcement £ 70,000 psi (483 MPa).
- \( yh \) = Cross-clauseal dimension of pile core measured center to center of hoop reinforcement, inch (mm).
- \( s \) = Spacing of transverse reinforcement measured along length of pile, inch (mm).
- \( A_{sh} \) = Cross-clauseal area of transverse reinforcement, square inches (mm²).
- \( f'c \) = Specified compressive strength of concrete, psi (MPa).

The hoops and cross ties shall be equivalent to deformed bars not less than No. 3 in size. Rectangular hoop ends shall terminate at a corner with seismic hooks.

Outside of the length of the pile requiring transverse confinement reinforcing, the spiral or hoop reinforcing with a volumetric ratio not less than one-half of that required for transverse confinement reinforcing shall be provided.

**18.10.3.8.3.4 Axial load limit in Seismic Design Categories C through F.**

For structures assigned to Seismic Design Category C, D, E, or F, the maximum factored axial load on precast prestressed piles subjected to a combination of seismic lateral force and axial load shall not exceed the following values:

1. 0.2f’c Ag for square piles
2. 0.4f’c Ag for circular or octagonal piles

**18.10.3.9 Cast-in-place deep foundations.**

Cast-in-place deep foundation elements shall be designed and detailed in accordance with Clauses 18.10.3.9.1 through 18.10.3.9.6.

**18.10.3.9.1 Design cracking moment.**

The design cracking moment (\( \phi Mn \)) for a cast-in-place deep foundation element not enclosed by
a structural steel pipe or tube shall be determined using the following equation:

\[ \phi M_n = 0.25 \sqrt{f_c S_m} \]

(Equation 18-10)

For SI:

\[ \phi M_n = 0.25 \sqrt{f_c S_m} \]

where:

- \( f_c \) = Specified compressive strength of concrete or grout, psi (MPa)
- \( S_m \) = Elastic clause modulus, neglecting reinforcement and casing, cubic inches (mm3).

**18.10.3.9.2 Required reinforcement.**

Where subject to uplift or where the required moment strength determined using the load combinations of this Code exceeds the design cracking moment determined in accordance with Clause 18.10.3.9.1, cast-in-place deep foundations not enclosed by a structural steel pipe or tube shall be reinforced.

**18.10.3.9.3 Placement of reinforcement.**

Reinforcement where required shall be assembled and tied together and shall be placed in the deep foundation element as a unit before the reinforced portion of the element is filled with concrete.

Exceptions:

1. Steel dowels embedded 1524 mm (5 feet) or less shall be permitted to be placed after concreting, while the concrete is still in a semifluid state.

2. For deep foundation elements installed with a hollow-stem auger, tied reinforcement shall be placed after elements are concreted, while the concrete is still in a semifluid state. Longitudinal reinforcement without lateral ties shall be placed either through the hollow stem of the auger prior to concreting or after concreting, while the concrete is still in a semifluid state.

3. For Group R-3 and U occupancies not exceeding two stories of light-frame construction, reinforcement is permitted to be placed after concreting, while the concrete is still in a semifluid state, and the concrete cover requirement is permitted to be reduced to 51 mm (2 inches), provided that the construction method can be demonstrated to the satisfaction of the building official.

**18.10.3.9.4 Seismic reinforcement.**

Where a structure is assigned to Seismic Design Category C, reinforcement shall be provided in accordance with Clause 18.10.3.9.4.1. Where a structure is assigned to Seismic Design Category D, E or F, reinforcement shall be provided in accordance with Clause 18.10.3.9.4.2.

Exceptions:

1. Isolated deep foundation elements supporting posts of Group R-3 and U occupancies not exceeding two stories of light-frame construction shall be permitted to be reinforced as required by rational analysis but with not less than one No. 4 bar, without ties or spirals, where detailed so the element is not subject to lateral loads and the soil provides adequate lateral support in accordance with Clause 18.10.2.1.

2. Isolated deep foundation elements supporting posts and bracing from decks and patios appurtenant to Group R-3 and U occupancies not exceeding two stories of light-frame construction shall be permitted to be reinforced as required by rational analysis but with not less than one No. 4 bar, without ties or spirals, where the lateral load, \( E \), to the top of the element does not exceed 890 N (200 pounds) and the soil provides adequate lateral support in accordance with Clause 18.10.2.1.

3. Deep foundation elements supporting the concrete foundation wall of Group R-
3 and U occupancies not exceeding two stories of light-frame construction shall be permitted to be reinforced as required by rational analysis but with not less than two No. 4 bars, without ties or spirals, where the design cracking moment determined in accordance with Clause 18.10.3.9.1 exceeds the required moment strength determined using the load combinations with overstrength factor in Clause 2.3.6 or 2.4.5 of ASCE 7 and the soil provides adequate lateral support in accordance with Clause 18.10.2.1.

4. Closed ties or spirals where required by Clause 18.10.3.9.4.2 shall be permitted to be limited to the top 914 mm (3 feet) of deep foundation elements 3048 mm (10 feet) or less in depth supporting Group R-3 and U occupancies of Seismic Design Category D, not exceeding two stories of light-frame construction.

18.10.3.9.4.1 Seismic reinforcement in Seismic Design Category C.

For structures assigned to Seismic Design Category C, cast-in-place deep foundation elements shall be reinforced as specified in this clause. Reinforcement shall be provided where required by analysis.

Not fewer than four longitudinal bars, with a minimum longitudinal reinforcement ratio of 0.0025, shall be provided throughout the minimum reinforced length of the element as defined in this clause starting at the top of the element. The minimum reinforced length of the element shall be taken as the greatest of the following:

1. One-third of the element length.
2. A distance of 3048 mm (10 feet).
3. Three times the least element dimension.
4. The distance from the top of the element to the point where the design cracking moment determined in accordance with Clause 18.10.3.9.1 exceeds the required moment strength determined using the load combinations of this Code.

Transverse reinforcement shall consist of closed ties or spirals with a minimum 9.5 mm (3/8 inch) diameter. Spacing of transverse reinforcement shall not exceed the smaller of 152 mm (6 inches) or 8-longitudinal-bar diameters, within a distance of three times the least element dimension from the bottom of the pile cap. Spacing of transverse reinforcement shall not exceed 16 longitudinal bar diameters throughout the remainder of the reinforced length.

Exceptions:

1. The requirements of this clause shall not apply to concrete cast in structural steel pipes or tubes.

2. A spiral-welded metal casing of a thickness not less than the manufacturer’s standard No. 14 gage (0.068 inch) is permitted to provide concrete confinement in lieu of the closed ties or spirals. Where used as such, the metal casing shall be protected against possible deleterious action due to soil constituents, changing water levels or other factors indicated by boring records of site conditions.

1. 18.10.3.9.4.2 Seismic reinforcement in Seismic Design Categories D through F.

2. For structures assigned to Seismic Design Category D, E or F, cast-in-place deep foundation elements shall be reinforced as specified in this clause. Reinforcement shall be provided where required by analysis.

3. Not fewer than four longitudinal bars, with a minimum longitudinal reinforcement ratio of 0.005, shall be provided throughout the minimum reinforced length of the element as defined in this clause starting at the top of the element. The minimum reinforced length of the element shall be taken as the greatest of the following:
1. One-half of the element length.

2. A distance of 3048 mm (10 feet).

3. Three times the least element dimension.

4. The distance from the top of the element to the point where the design cracking moment determined in accordance with Clause 18.10.3.9.1 exceeds the required moment strength determined using the load combinations of this Code.

Transverse reinforcement shall consist of closed ties or spirals not smaller than No. 3 bars for elements with a least dimension up to 508 mm (20 inches), and No. 4 bars for larger elements. Throughout the remainder of the reinforced length outside the regions with transverse confinement reinforcement, as specified in Clause 18.10.3.9.4.2.1 or 18.10.3.9.4.2.2, the spacing of transverse reinforcement shall not exceed the least of the following:

1. 12 longitudinal bar diameters.

2. One-half the least dimension of the element.

3. 12 inches (305 mm).

Exceptions:

1. The requirements of this clause shall not apply to concrete cast in structural steel pipes or tubes.

2. A spiral-welded metal casing of a thickness not less than manufacturer’s standard No. 14 gage (0.068 inch) is permitted to provide concrete confinement in lieu of the closed ties or spirals. Where used as such, the metal casing shall be protected against possible deleterious action due to soil constituents, changing water levels or other factors indicated by boring records of site conditions.

18.10.3.9.4.2.1 Site Classes A through D.

For Site Class A, B, C or D sites, transverse confinement reinforcement shall be provided in the element in accordance with Clauses 18.7.5.2, 18.7.5.3 and 18.7.5.4 of ACI 318 within three times the least element dimension of the bottom of the pile cap. A transverse spiral reinforcement ratio of not less than one-half of that required in Clause 18.7.5.4(a) of ACI 318 shall be permitted.

18.10.3.9.4.2.2 Site Classes E and F.

For Site Class E or F sites, transverse confinement reinforcement shall be provided in the element in accordance with Clauses 18.7.5.2, 18.7.5.3 and 18.7.5.4 of ACI 318 within seven times the least element dimension of the pile cap and within seven times the least element dimension of the interfaces of strata that are hard or stiff and strata that are liquefiable or are composed of soft- to medium-stiff clay.

18.10.3.9.5 Belled drilled shafts.

Where drilled shafts are belled at the bottom, the edge thickness of the bell shall be not less than that required for the edge of footings. Where the sides of the bell slope at an angle less than 60 degrees (1 rad) from the horizontal, the effects of vertical shear shall be considered.

18.10.3.9.6 Socketed drilled shafts.

Socketed drilled shafts shall have a permanent pipe or tube casing that extends down to bedrock and an uncased socket drilled into the bedrock, both filled with concrete. Socketed drilled shafts shall have reinforcement or a structural steel core for the length as indicated by an approved method of analysis.

The depth of the rock socket shall be sufficient to develop the full load-bearing capacity of the element with a minimum safety factor of two, but the depth shall be not less than the outside diameter of the pipe or tube casing. The design of the rock socket is permitted to be predicated on the sum of the allowable load-bearing pressure on the bottom of the socket plus bond along the sides of the socket.
Where a structural steel core is used, the gross cross-clauseal area of the core shall not exceed 25 percent of the gross area of the drilled shaft.

18.10.3.10 Micropiles.

Micropiles shall be designed and detailed in accordance with Clauses 18.10.3.10.1 through 18.10.3.10.4.

18.10.3.10.1 Construction.

Micropiles shall develop their load-carrying capacity by means of a bond zone in soil, bedrock or a combination of soil and bedrock. Micropiles shall be grouted and have either a steel pipe or tube or steel reinforcement at every clause along the length. It shall be permitted to transition from deformed reinforcing bars to steel pipe or tube reinforcement by extending the bars into the pipe or tube clause by not less than their development length in tension in accordance with ACI 318.

18.10.3.10.2 Materials.

Reinforcement shall consist of deformed reinforcing bars in accordance with ASTM A615 Grade 60 or 75 or ASTM A722 Grade 150. The steel pipe or tube shall have a minimum wall thickness of 4.8 mm (3/16 inch). Splices shall comply with Clause 18.10.3.6. The steel pipe or tube shall have a minimum yield strength of 310 MPa (45,000 psi) and a minimum elongation of 15 percent as shown by mill certifications or two coupon test samples per 18160 kg (40,000 pounds) of pipe or tube.

18.10.3.10.3 Reinforcement.

For micropiles or portions thereof grouted inside a temporary or permanent casing or inside a hole drilled into bedrock or a hole drilled with grout, the steel pipe or tube or steel reinforcement shall be designed to carry not less than 40 percent of the design compression load. Micropiles or portions thereof grouted in an open hole in soil without temporary or permanent casing and without suitable means of verifying the hole diameter during grouting shall be designed to carry the entire compression load in the reinforcing steel. Where a steel pipe or tube is used for reinforcement, the portion of the grout enclosed within the pipe is permitted to be included in the determination of the allowable stress in the grout.

18.10.3.10.4 Seismic reinforcement.

For structures assigned to Seismic Design Category C, a permanent steel casing shall be provided from the top of the micropile down to the point of zero curvature. For structures assigned to Seismic Design Category D, E or F, the micropile shall be considered as an alternative system in accordance with this Code. The alternative system design, supporting documentation and test data shall be submitted to the building official for review and approval.

18.10.3.11 Pile caps.

Pile caps shall be of reinforced concrete, and shall include all elements to which vertical deep foundation elements are connected, including grade beams and mats. The soil immediately below the pile cap shall not be considered as carrying any vertical load, with the exception of a combined pile raft. The tops of vertical deep foundation elements shall be embedded not less than 76 mm (3 inches) into pile caps and the caps shall extend not less than 102 mm (4 inches) beyond the edges of the elements. The tops of elements shall be cut or chipped back to sound material before capping.

18.10.3.11.1 Seismic Design Categories C through F.

For structures assigned to Seismic Design Category C, D, E or F, concrete deep foundation elements shall be connected to the pile cap by embedding the element reinforcement or field-placed dowels anchored in the element into the pile cap for a distance equal to their development length in accordance with ACI 318. It shall be permitted to connect precast prestressed piles to the pile cap by developing the element prestressing strands into the pile cap provided that the connection is ductile. For deformed bars, the development length is the full development length for compression, or
tension in the case of uplift, without reduction for excess reinforcement in accordance with Clause 25.4.10 of ACI 318. Alternative measures for laterally confining concrete and maintaining toughness and ductile-like behavior at the top of the element shall be permitted provided that the design is such that any hinging occurs in the confined region.

The minimum transverse steel ratio for confinement shall be not less than one-half of that required for columns.

For resistance to uplift forces, anchorage of steel pipes, tubes or H-piles to the pile cap shall be made by means other than concrete bond to the bare steel clause. Concrete-filled steel pipes or tubes shall have reinforcement of not less than 0.01 times the cross-clauseal area of the concrete fill developed into the cap and extending into the fill a length equal to two times the required cap embedment, but not less than the development length in tension of the reinforcement.

18.10.3.11.2 Seismic Design Categories D through F.

For structures assigned to Seismic Design Category D, E or F, deep foundation element resistance to uplift forces or rotational restraint shall be provided by anchorage into the pile cap, designed considering the combined effect of axial forces due to uplift and bending moments due to fixity to the pile cap. Anchorage shall develop not less than 25 percent of the strength of the element in tension. Anchorage into the pile cap shall comply with the following:

1. In the case of uplift, the anchorage shall be capable of developing the least of the following:

   1.1. The nominal tensile strength of the longitudinal reinforcement in a concrete element.

   1.2. The nominal tensile strength of a steel element.

   1.3. The frictional force developed between the element and the soil multiplied by 1.3.

Exception: The anchorage is permitted to be designed to resist the axial tension force resulting from the seismic load effects including overstrength factor in accordance with Clause 2.3.6 or 2.4.5 of ASCE 7.

2. In the case of rotational restraint, the anchorage shall be designed to resist the axial and shear forces, and moments resulting from the seismic load effects including overstrength factor in accordance with Clause 2.3.6 or 2.4.5 of ASCE 7 or the anchorage shall be capable of developing the full axial, bending and shear nominal strength of the element.

Where the vertical lateral-force-resistant elements are columns, the pile cap flexural strengths shall exceed the column flexural strength. The connection between batter piles and pile caps shall be designed to resist the nominal strength of the pile acting as a short column. Batter piles and their connection shall be designed to resist forces and moments that result from the application of seismic load effects including overstrength factor in accordance with Clause 2.3.6 or 2.4.5 of ASCE 7.

18.10.3.12 Grade beams.

For structures assigned to Seismic Design Category D, E or F, grade beams shall comply with the provisions in Clause 18.13.3 of ACI 318 for grade beams, except where they are designed to resist the seismic load effects including overstrength factor in accordance with Clause 2.3.6 or 2.4.5 of ASCE 7.

18.10.3.13 Seismic ties.

For structures assigned to Seismic Design Category C, D, E or F, individual deep foundations shall be interconnected by ties. Unless it can be demonstrated that equivalent restraint is provided by reinforced concrete beams within slabs on grade or reinforced concrete slabs on grade or confinement by competent rock, hard cohesive soils or very dense granular soils, ties shall be capable of carrying, in tension or compression, a force equal to the lesser of the product of the larger pile cap or column design gravity load times the seismic coefficient, SDS, divided by 10, and 25.
percent of the smaller pile or column design gravity load.

**Exception:** In Group R-3 and U occupancies of light-frame construction, deep foundation elements supporting foundation walls, isolated interior posts detailed so the element is not subject to lateral loads or exterior decks and patios are not subject to interconnection where the soils are of adequate stiffness, subject to the approval of the building official.

**18.10.4 Installation.**

Deep foundations shall be installed in accordance with Clause 18.10.4. Where a single deep foundation element comprises two or more clauses of different materials or different types spliced together, each clause shall satisfy the applicable conditions of installation.

**18.10.4.1 Structural integrity.**

Deep foundation elements shall be installed in such a manner and sequence as to prevent distortion or damage that would adversely affect the structural integrity of adjacent structures or of foundation elements being installed or already in place and as to avoid compacting the surrounding soil to the extent that other foundation elements cannot be installed properly.

**18.10.4.1.1 Compressive strength of precast concrete piles.**

A precast concrete pile shall not be driven before the concrete has attained a compressive strength of not less than 75 percent of the specified compressive strength (f’c), but not less than the strength sufficient to withstand handling and driving forces.

**18.10.4.1.2 Casing.**

Where cast-in-place deep foundation elements are formed through unstable soils and concrete is placed in an open-drilled hole, a casing shall be inserted in the hole prior to placing the concrete. Where the casing is withdrawn during concreting, the level of concrete shall be

18.10.4.3 Driving near uncased concrete.

Deep foundation elements shall not be driven within six element diameters centre to centre in granular soils or within one-half the element length in cohesive soils of an uncased element filled with concrete less than 48 hours old unless approved by the building official. If the concrete surface in any completed element rises or drops, the element shall be replaced. Driven uncased deep foundation elements shall not be installed in soils that could cause heave.

18.10.4.4 Driving near cased concrete.

Deep foundation elements shall not be driven within four and one-half average diameters of a cased element filled with concrete less than 24 hours old unless approved by the building official. Concrete shall not be placed in casings within heave range of driving.

18.10.4.5 Defective timber piles.

Any substantial sudden change in rate of penetration of a timber pile shall be investigated for possible damage. If the sudden change in rate of penetration cannot be correlated to soil strata, the pile shall be removed for inspection or rejected.

18.10.4.6 Identification.

Deep foundation materials shall be identified for conformity to the specified grade with this identity maintained continuously from the point of manufacture to the point of installation or shall be tested by an approved agency to determine conformity to the specified grade. The approved agency shall furnish an affidavit of compliance to the building official.
18.10.4.3 Location plan.

A plan showing the location and designation of deep foundation elements by an identification system shall be filed with the building official prior to installation of such elements. Detailed records for elements shall bear an identification corresponding to that shown on the plan.

18.10.4.4 Preexcavation.

The use of jetting, augering or other methods of preexcavation shall be subject to the approval of the building official. Where permitted, preexcavation shall be carried out in the same manner as used for deep foundation elements subject to load tests and in such a manner that will not impair the carrying capacity of the elements already in place or damage adjacent structures. Element tips shall be advanced below the preexcavated depth until the required resistance or penetration is obtained.

18.10.4.5 Vibratory driving.

Vibratory drivers shall only be used to install deep foundation elements where the element load capacity is verified by load tests in accordance with Clause 18.10.3.3.1.2. The installation of production elements shall be controlled according to power consumption, rate of penetration or other approved means that ensure element capacities equal or exceed those of the test elements.

18.10.4.6 Heaved elements.

Deep foundation elements that have heaved during the driving of adjacent elements shall be redriven as necessary to develop the required capacity and penetration, or the capacity of the element shall be verified by load tests in accordance with Clause 18.10.3.3.1.2.

18.10.4.7 Enlarged base cast-in-place elements.

Enlarged bases for cast-in-place deep foundation elements formed by compacting concrete or by driving a precast base shall be formed in or driven into granular soils. Such elements shall be constructed in the same manner as successful prototype test elements driven for the project. Shafts extending through peat or other organic soil shall be encased in a permanent steel casing. Where a cased shaft is used, the shaft shall be adequately reinforced to resist column action or the annular space around the shaft shall be filled sufficiently to reestablish lateral support by the soil. Where heave occurs, the element shall be replaced unless it is demonstrated that the element is undamaged and capable of carrying twice its design load.

18.10.4.8 Hollow-stem augered, cast-in-place elements.

Where concrete or grout is placed by pumping through a hollow-stem auger, the auger shall be permitted to rotate in a clockwise direction during withdrawal. As the auger is withdrawn at a steady rate or in increments not to exceed 305 mm (1 foot), concreting or grouting pumping pressures shall be measured and maintained high enough at all times to offset hydrostatic and lateral earth pressures. Concrete or grout volumes shall be measured to ensure that the volume of concrete or grout placed in each element is equal to or greater than the theoretical volume of the hole created by the auger. Where the installation process of any element is interrupted or a loss of concreting or grouting pressure occurs, the element shall be redrilled to 1524 mm (5 feet) below the elevation of the tip of the auger when the installation was interrupted or concrete or grout pressure was lost and reformed. Augered cast-in-place elements shall not be installed within six diameters center to center of an element filled with concrete or grout less than 12 hours old, unless approved by the building official. If the concrete or grout level in any completed element drops due to installation of an adjacent element, the element shall be replaced.

18.10.4.9 Socketed drilled shafts.

The rock socket and pipe or tube casing of socketed drilled shafts shall be thoroughly cleaned of foreign materials before filling with concrete. Steel cores shall be bedded in cement grout at the base of the rock socket.
18.10.4.10 Micropiles.

Micropile deep foundation elements shall be permitted to be formed in holes advanced by rotary or percussive drilling methods, with or without casing. The elements shall be grouted with a fluid cement grout. The grout shall be pumped through a tremie pipe extending to the bottom of the element until grout of suitable quality returns at the top of the element. The following requirements apply to specific installation methods:

1. For micropiles grouted inside a temporary casing, the reinforcing bars shall be inserted prior to withdrawal of the casing. The casing shall be withdrawn in a controlled manner with the grout level maintained at the top of the element to ensure that the grout completely fills the drill hole. During withdrawal of the casing, the grout level inside the casing shall be monitored to verify that the flow of grout inside the casing is not obstructed.

2. For a micropile or portion thereof grouted in an open drill hole in soil without temporary casing, the minimum design diameter of the drill hole shall be verified by a suitable device during grouting.

3. For micropiles designed for end bearing, a suitable means shall be employed to verify that the bearing surface is properly cleaned prior to grouting.

4. Subsequent micropiles shall not be drilled near elements that have been grouted until the grout has had sufficient time to harden.

5. Micropiles shall be grouted as soon as possible after drilling is completed.

6. For micropiles designed with a full-length casing, the casing shall be pulled back to the top of the bond zone and reinserted or some other suitable means employed to ensure grout coverage outside the casing.

18.10.4.11 Helical piles.

Helical piles shall be installed to specified embedment depth and torsional resistance criteria as determined by a registered design professional. The torque applied during installation shall not exceed the maximum allowable installation torque of the helical pile.

18.10.4.12 Special inspection.

Special inspections in accordance with Clause 19.5.7 and 19.5.8 shall be provided for driven and cast-in-place deep foundation elements, respectively. Special inspections in accordance with Clause 19.5.9 shall be provided for helical piles.
PART 19: SPECIAL INSPECTIONS AND TESTS

User notes:
About this part: Part 19 provides a variety of procedures and criteria for testing materials and assemblies, and labelling materials and assemblies. Its key purposes are to establish where additional inspections/observations and testing must be provided, and the Submissions and verifications that must be provided to the Head of the works department. This part expands on the inspections of Part 1 by requiring special inspection by a qualified individual where indicated and, in some cases, structural observation by a registered design professional. Quality assurance measures that verify proper assembly of structural components and the suitability of the installed materials are intended to provide a building that, once constructed, complies with the minimum structural and fire-resistance Code requirements as well as the approved design. To determine this compliance often requires frequent inspections and testing at specific stages of construction.

19.1 GENERAL

19.1.1 Scope.
The provisions of this part shall govern the quality, workmanship and requirements for materials covered. Materials of construction and tests shall conform to the applicable standards listed in this Code.

19.2 NEW MATERIALS

19.2.1 General.
New building materials, equipment, appliances, systems or methods of construction not provided for in this Code, and any material of questioned suitability proposed for use in the construction of a building or structure, shall be subjected to the tests prescribed in this part and in the approved rules to determine character, quality and limitations of use.

19.3 APPROVALS

19.3.1 Approved agency.
An approved agency shall provide all information as necessary for the Head of the works department to determine that the agency meets the applicable requirements specified in Clauses 19.3.1.1 through 19.3.1.3.

19.3.1.1 Independence.
An approved agency shall be objective, competent and independent from the contractor responsible for the work being inspected. The agency shall disclose to the Head of the works department and the registered design professional in responsible charge possible conflicts of interest so that objectivity can be confirmed.

19.3.1.2 Equipment.
An approved agency shall have adequate equipment to perform required tests. The equipment shall be periodically calibrated by an approved agency.

19.3.1.3 Personnel.
An approved agency shall employ experienced personnel educated in conducting, supervising and evaluating tests and special inspections.

19.3.2 Written approval.
Any material, appliance, equipment, system or method of construction meeting the requirements of this Code shall be approved in writing after satisfactory completion of the required tests and submission of required test reports.

19.3.3 Record of approval.
For any material, appliance, equipment, system or method of construction that has been approved, a record of such approval, including the conditions and limitations of the approval, shall be kept on file in the Head of the works department’s office and shall be available for public review at appropriate times.
19.3.4 Performance.

Specific information consisting of test reports conducted by an approved agency in accordance with the appropriate referenced standards, or other such information as necessary, shall be provided for the Head of the works department to determine that the product, material or assembly meets the applicable Code requirements.

19.3.4.1 Research and investigation.

Sufficient technical data shall be submitted to the Head of the works department to substantiate the proposed use of any product, material or assembly. If it is determined that the evidence submitted is satisfactory proof of performance for the use intended, the Head of the works department shall approve the use of the product, material or assembly subject to the requirements of this Code. The costs, reports and investigations required under these provisions shall be paid by the owner or the owner’s authorized agent.

19.3.4.2 Research reports.

Supporting data, where necessary to assist in the approval of products, materials or assemblies not specifically provided for in this Code, shall consist of valid research reports from approved sources.

19.3.5 Labelling.

Products, materials or assemblies required to be labelled shall be labelled in accordance with the procedures set forth in Clauses 19.3.5.1 through 19.3.5.4 and in the provision of LI 1541 (Ghana Standard General labelling rules).

19.3.5.1 Testing.

An approved agency shall test a representative sample of the product, material or assembly being labelled to the relevant standard or standards. The approved agency shall maintain a record of the tests performed. The record shall provide sufficient detail to verify compliance with the test standard.

19.3.5.2 Inspection and identification.

The approved agency shall periodically perform an inspection, which shall be in-plant if necessary, of the product or material that is to be labelled. The inspection shall verify that the labelled product, material or assembly is representative of the product, material or assembly tested.

19.3.5.3 Label information.

The label shall contain the manufacturer’s identification, model number, serial number or definitive information describing the performance characteristics of the product, material or assembly and the approved agency’s identification.

19.3.5.4 Method of labelling.

Information required to be permanently identified on the product, material or assembly shall be acid etched, sand blasted, ceramic fired, laser etched, embossed or of a type that, once applied, cannot be removed without being destroyed.

19.3.6 Evaluation and follow-up inspection services.

Where structural components or other items regulated by this Code are not visible for inspection after completion of a prefabricated assembly, the owner or the owner’s authorized agent shall submit a report of each prefabricated assembly. The report shall indicate the complete details of the assembly, including a description of the assembly and its components, the basis upon which the assembly is being evaluated, test results and similar information and other data as necessary for the Head of the works department to determine conformance to this Code. Such a report shall be approved by the Head of the works department.

19.3.6.1 Follow-up inspection.

The owner or the owner’s authorized agent shall provide for special inspections of fabricated items in accordance with Clause 19.4.2.5.
19.3.6.2 Test and inspection records.

Copies of necessary test and special inspection records shall be filed with the Head of the works department.

19.4 SPECIAL INSPECTIONS AND TESTS, CONTRACTOR RESPONSIBILITY AND STRUCTURAL OBSERVATION

19.4.1 General.

Special inspections and tests, statements of special inspections, responsibilities of contractors, Submissions to the Head of the works department and structural observations shall meet the applicable requirements of this clause.

19.4.2 Special inspections and tests.

Where application is made to the Head of Works for construction as specified in this Code, the owner or the owner’s authorized agent, other than the contractor, shall employ one or more approved agencies to provide special inspections and tests during construction on the types of work specified in Clause 19.5 and identify the approved agencies to the Head of Works. These special inspections and tests are in addition to the inspections by the Head of Works that are identified in this Code.

Exceptions:

1. Special inspections and tests are not required for construction of a minor nature or as warranted by conditions in the jurisdiction as approved by the Head of the works department.

2. Special inspections and tests are not required for portions of structures designed and constructed in accordance with the cold-formed steel light-frame construction provisions of Clause 23.11.1.2 or the conventional light-frame construction provisions of Clause 24.8.

3. The contractor shall employ the approved agencies where the contractor is also the owner.

19.4.2.1 Special inspector qualifications.

Prior to the start of the construction, the approved agencies shall provide written documentation to the Head of Works demonstrating the competence and relevant experience or training of the special inspectors who will perform the special inspections and tests during construction. Experience or training shall be considered to be relevant where the documented experience or training is related in complexity to the same type of special inspection or testing activities for projects of similar complexity and material qualities. These qualifications are in addition to qualifications specified in other clauses of this Code.

The registered design professional in responsible charge and engineers of record involved in the design of the project are permitted to act as the approved agency and their personnel are permitted to act as special inspectors for the work designed by them, provided they qualify as special inspectors.

19.4.2.2 Access for special inspection.

The construction or work for which special inspection or testing is required shall remain accessible and exposed for special inspection or testing purposes until completion of the required special inspections or tests.

19.4.2.3 Statement of special inspections.

The applicant shall submit a statement of special inspections in accordance with this Code as a condition for permit issuance. This statement shall be in accordance with Clause 19.4.3.

Exception: A statement of special inspections is not required for portions of structures designed and constructed in accordance with the cold-formed steel light-frame construction provisions
of Clause 23.11.2 or the conventional light-frame construction provisions of Clause 24.8.

19.4.2.4 Report requirement.

Approved agencies shall keep records of special inspections and tests. The approved agency shall submit reports of special inspections and tests to the Head of the works department and to the registered design professional in responsible charge. Reports shall indicate that work inspected or tested was or was not completed in conformance to approved construction documents. Discrepancies shall be brought to the immediate attention of the contractor for correction. If they are not corrected, the discrepancies shall be brought to the attention of the Head of the works department and to the registered design professional in responsible charge prior to the completion of that phase of the work. A final report documenting required special inspections and tests, and correction of any discrepancies noted in the inspections or tests, shall be submitted at a point in time agreed upon prior to the start of work by the owner or the owner’s authorized agent to the Head of the works department.

19.4.2.5 Special inspection of fabricated items.

Where fabrication of structural, load-bearing or lateral load-resisting members or assemblies is being conducted on the premises of a fabricator’s shop, special inspections of the fabricated items shall be performed during fabrication, except where the fabricator has been approved to perform work without special inspections in accordance with Clause 19.4.2.5.1.

19.4.2.5.1 Fabricator approval.

Special inspections during fabrication are not required where the work is done on the premises of a fabricator approved to perform such work without special inspection. Approval shall be based on review of the fabricator’s written fabrication procedures and quality control manuals that provide a basis for control of materials and workmanship, with periodic auditing of fabrication and quality control practices by an approved agency or the Head of the works department. At completion of fabrication, the approved fabricator shall submit a certificate of compliance to the owner or the owner’s authorized agent for Submission to the Head of the works department as specified in Clause 19.4.5 stating that the work was performed in accordance with the approved construction documents.

19.4.3 Statement of special inspections.

Where special inspections or tests are required by Clause 19.5, the registered design professional in responsible charge shall prepare a statement of special inspections in accordance with Clause 19.4.3.1 for Submission by the applicant in accordance with Clause 19.4.2.3.

Exception: The statement of special inspections is permitted to be prepared by a qualified person approved by the Head of the works department for construction not designed by a registered design professional.

19.4.3.1 Content of statement of special inspections.

The statement of special inspections shall identify the following:

1. The materials, systems, components and work required to have special inspections or tests by the Head of the works department or by the registered design professional responsible for each portion of the work.

2. The type and extent of each special inspection.

3. The type and extent of each test.

4. Additional requirements for special inspections or tests for seismic or wind resistance as specified in Clauses 19.5.11, 19.5.12 and 19.5.13.

5. For each type of special inspection, identification as to whether it will be continuous special inspection, periodic special inspection or performed in
accordance with the notation used in the referenced standard where the inspections are defined.

19.4.3.2 Seismic requirements in the statement of special inspections.

Where Clause 19.5.12 or 19.5.13 specifies special inspections or tests for seismic resistance, the statement of special inspections shall identify the designated seismic systems and seismic force-resisting systems that are subject to the special inspections or tests.

19.4.3.3 Wind requirements in the statement of special inspections.

Where Clause 19.5.11 specifies special inspection for wind resistance, the statement of special inspections shall identify the main windforce-resisting systems and wind-resisting components that are subject to special inspections.

19.4.4 Contractor responsibility.

Each contractor responsible for the construction of a main wind- or seismic force-resisting system, designated seismic system or a wind- or seismic force-resisting component listed in the statement of special inspections shall submit a written statement of responsibility to the Head of the works department and the owner or the owner's authorized agent prior to the commencement of work on the system or component. The contractor's statement of responsibility shall contain acknowledgement of awareness of the special requirements contained in the statement of special inspections.

19.4.5 Submissions to the Head of the works department.

In addition to the Submission of reports of special inspections and tests in accordance with Clause 19.4.2.4, reports and certificates shall be submitted by the owner or the owner's authorized agent to the Head of the works department for each of the following:

1. Certificates of compliance for the fabrication of structural, load-bearing or lateral load-resisting members or assemblies on the premises of an approved fabricator in accordance with Clause 19.4.2.5.1.

2. Certificates of compliance for the seismic qualification of nonstructural components, supports and attachments in accordance with Clause 19.5.13.2.

3. Certificates of compliance for designated seismic systems in accordance with Clause 19.5.13.3.

4. Reports of preconstruction tests for shotcrete in accordance with Clause 20.8.5.

5. Certificates of compliance for open web steel joists and joist girders in accordance with Clause 23.7.5.

6. Reports of tests of material properties verifying compliance with the requirements of GS 788 for weldability and in this Code for reinforcing bars in concrete complying with a standard other than ASTM A706 that are to be welded.

7. Reports of mill tests in accordance with this Code for reinforcing bars complying with ASTM A615 and used to resist earthquake-induced flexural or axial forces in the special moment frames, special structural walls or coupling beams connecting special structural walls of seismic force-resisting systems in structures assigned to Seismic Design Zones.

19.4.6 Structural observations.

Where required by the provisions of Clause 19.4.6.1, 19.4.6.2 or 19.4.6.3, the owner or the owner's authorized agent shall employ a registered design professional to perform
structural observations. Structural observation does not include or waive the responsibility for the inspections in this Code or the special inspections in Clause 19.5 or other clauses of this Code.

Prior to the commencement of observations, the structural observer shall submit to the Head of the works department a written statement identifying the frequency and extent of structural observations.

At the conclusion of the work included in the permit, the structural observer shall submit to the Head of the works department a written statement that the site visits have been made and identify any reported deficiencies that, to the best of the structural observer's knowledge, have not been resolved.

19.4.6.1 Structural observations for structures.

Structural observations shall be provided for those structures where one or more of the following conditions exist:

1. The structure is classified as Risk Category IV.
2. The structure is a high-rise building.
3. Such observation is required by the registered design professional responsible for the structural design.
4. Such observation is specifically required by the Head of the works department.

19.4.6.2 Structural observations for seismic resistance.

Structural observations shall be provided for those structures assigned to Seismic Design Category D, E or F where one or more of the following conditions exist:

1. The structure is classified as Risk Category III or IV.
2. The structure is assigned to Seismic Design Category E, is classified as Risk Category I or II, and is greater than two stories above the grade plane.

19.4.6.3 Structural observations for wind resistance.

Structural observations shall be provided for those structures sited where V is 130 mph (58 m/sec) or greater and the structure is classified as Risk Category III or IV.

19.5 REQUIRED SPECIAL INSPECTIONS AND TESTS

19.5.1 General.

Special inspections and tests of elements and nonstructural components of buildings and structures shall meet the applicable requirements of this clause.

19.5.1.1 Special cases.

Special inspections and tests shall be required for proposed work that is, in the opinion of the Head of the works department, unusual in its nature, such as, but not limited to, the following examples:

1. Construction materials and systems that are alternatives to materials and systems prescribed by this Code.
2. Unusual design applications of materials described in this Code.
3. Materials and systems required to be installed in accordance with additional manufacturer's instructions that prescribe requirements not contained in this Code or in standards referenced by this Code.

19.5.2 Steel construction.

The special inspections and nondestructive testing of steel construction in buildings, structures, and portions thereof shall be in accordance with this clause.
Exception: Special inspections of the steel fabrication process shall not be required where the fabrication process for the entire building or structure does not include any welding, thermal cutting or heating operation of any kind. In such cases, the fabricator shall be required to submit a detailed procedure for material control that demonstrates the fabricator's ability to maintain suitable records and procedures such that, at any time during the fabrication process, the material specification and grade for the main stress-carrying elements are capable of being determined. Mill test reports shall be identifiable to the main stress-carrying elements where required by the approved construction documents.

19.5.2.1 Structural steel.

Special inspections and nondestructive testing of structural steel elements in buildings, structures and portions thereof shall be in accordance with the quality assurance inspection requirements of ISO/IEC 17023.

Exception: Special inspection of railing systems composed of structural steel elements shall be limited to welding inspection of welds at the base of cantilevered rail posts.

19.5.2.2 Cold-formed steel deck.

Special inspections and qualification of welding special inspectors for cold-formed steel floor and roof deck shall be in accordance with the quality assurance inspection requirements of ISO/IEC 17023

19.5.2.3 Open-web steel joists and joist girders.

Special inspections of open-web steel joists and joist girders in buildings, structures and portions thereof shall be in accordance with Table 19.5.2.3.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTINUOUS SPECIAL INSPECTION</th>
<th>PERIODIC SPECIAL INSPECTION</th>
<th>REFERENCED STANDARDa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Installation of open-web steel joists and joist girders.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. End connections – welding or bolted.</td>
<td>—</td>
<td>X</td>
<td>SJI specifications listed in this Code</td>
</tr>
<tr>
<td>b. Bridging – horizontal or diagonal.</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1. Standard bridging.</td>
<td>—</td>
<td>X</td>
<td>SJI specifications listed in this Code</td>
</tr>
<tr>
<td>2. Bridging that differs from the SJI specifications listed in Clause 23.7.1.</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.
a. Where applicable, see Clause 19.5.12, Special inspections for seismic resistance.

19.5.2.4 Cold-formed steel trusses spanning 18 metres or greater.

Where a cold-formed steel truss clear span is 18 m (approx. 60 feet) or greater, the special inspector shall verify that the temporary installation restraint/bracing and the permanent individual truss member restraint/bracing are installed in accordance with the approved truss Submission package.

19.5.3 Concrete construction.

Special inspections and tests of concrete construction shall be performed in accordance with this clause and Table 19.5.3.

**Exception:** Special inspections and tests shall not be required for:

1. Isolated spread concrete footings of buildings three stories or less above grade plane that are fully supported on earth or rock.

2. Continuous concrete footings supporting walls of buildings three stories or less above grade plane that are fully supported on earth or rock where:

   2.1. The footings support walls of light-frame construction.

   2.2. The footings are designed in accordance with this code.

   2.3. The structural design of the footing is based on a specified compressive strength, $f_{c}$, not more than 2,500 pounds per square inch (psi) (17.2 MPa), regardless of the compressive strength specified in the approved construction documents or used in the footing construction.

3. Nonstructural concrete slabs supported directly on the ground, including prestressed slabs on grade, where the effective prestress in the concrete is less than 1.03 MPa (150 psi).

4. Concrete foundation walls constructed in accordance with Table 18.7.1.6.2.

5. Concrete patios, driveways and sidewalks, on grade.
### TABLE 19.5.3
REQUIRED SPECIAL INSPECTIONS AND TESTS OF CONCRETE CONSTRUCTION

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTINUOUS SPECIAL INSPECTION</th>
<th>PERIODIC SPECIAL INSPECTION</th>
<th>REFERENCED STANDARD</th>
<th>IBC REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inspect reinforcement, including prestressing tendons, and verify</td>
<td>—</td>
<td>X</td>
<td>ACI 318: Ch. 20, 25.2, 25.3, 26.6.1-26.6.3</td>
<td>1908.4</td>
</tr>
<tr>
<td>2. Reinforcing bar welding:</td>
<td>—</td>
<td>X</td>
<td>AWS D1.4</td>
<td></td>
</tr>
<tr>
<td>a. Verify weldability of reinforcing bars other than ASTM A706:</td>
<td>—</td>
<td>X</td>
<td>ACI 318: 20.6.4</td>
<td>—</td>
</tr>
<tr>
<td>b. Inspect single-pass fillet welds, maximum 7/16&quot;, and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Inspect all other welds.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Inspect anchors cast in concrete.</td>
<td>—</td>
<td>X</td>
<td>ACI 318: 17.8.2</td>
<td>—</td>
</tr>
<tr>
<td>4. Inspect anchors posi-installed in hardened concrete members.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Adhesive anchors installed in horizontally or upwardly inclined</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>orientations to resist sustained tension loads.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Mechanical anchors and adhesive anchors not defined in 4a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Verify use of required design mix.</td>
<td>—</td>
<td>X</td>
<td>ACI 318: Ch. 19,</td>
<td>1904.1, 1904.2,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>26.4.3, 26.4.4</td>
<td>1908.2, 1908.3</td>
</tr>
<tr>
<td>6. Prior to concrete placement, fabricate specimens for strength</td>
<td>X</td>
<td>—</td>
<td>ASTM C1/72</td>
<td>1908.10</td>
</tr>
<tr>
<td>test, perform slump and air content tests, and determine the</td>
<td></td>
<td></td>
<td>ASTM C31</td>
<td></td>
</tr>
<tr>
<td>temperature of the concrete.</td>
<td></td>
<td></td>
<td>ACI 318: 26.5, 26.12</td>
<td></td>
</tr>
<tr>
<td>7. Inspect concrete and shotcrete placement for proper application</td>
<td>X</td>
<td>—</td>
<td>ACI 318: 26.5</td>
<td>1908.6, 1908.7,</td>
</tr>
<tr>
<td>techniques.</td>
<td></td>
<td></td>
<td></td>
<td>1908.8</td>
</tr>
<tr>
<td>8. Verify maintenance of specified curing temperature and</td>
<td>—</td>
<td>X</td>
<td>ACI 318: 26.5.3-26.5.5</td>
<td>1908.9</td>
</tr>
<tr>
<td>techniques.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Application of prestressing forces; and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Grouting of bonded prestressing tendons.</td>
<td>X</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Inspect erection of precast concrete members.</td>
<td>—</td>
<td>X</td>
<td>ACI 318: 26.9</td>
<td>—</td>
</tr>
<tr>
<td>11. Verify in-situ concrete strength, prior to stressing of</td>
<td>—</td>
<td>X</td>
<td>ACI 318: 26.11.2</td>
<td>—</td>
</tr>
<tr>
<td>tendons in post-tensioned concrete and prior to removal of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>shores and forms from beams and structural slabs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Inspect formwork for shape, location and</td>
<td>—</td>
<td>X</td>
<td>ACI 318: 26.11.1.2(b)</td>
<td>—</td>
</tr>
<tr>
<td>dimensions of the concrete member being formed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm.

- a. Where applicable, see Clause 19.5.12. Special inspections for seismic resistance.
- b. Specific requirements for special inspection shall be included in the research report for the anchor issued by an approved source in accordance with this Code or other qualification procedures. Where specific requirements are not provided, special inspection requirements shall be specified by the registered design professional and shall be approved by the Head of the works department prior to the commencement of the work.

#### 19.5.3.1 Welding of reinforcing bars.

Special inspections of welding and qualifications of special inspectors for reinforcing bars shall be in accordance with the requirements of GS 788 for special inspection and of this Code for special inspector qualification.

#### 19.5.3.2 Material tests.

In the absence of sufficient data or documentation providing evidence of conformance to quality standards for materials in this Code, the Head of the works department shall require testing of materials in accordance with the appropriate standards and criteria for the material in this Code.
19.5.4 Masonry construction.

Special inspections and tests of masonry construction shall be performed in accordance with the quality assurance program requirements of this Code.

Exception: Special inspections and tests shall not be required for:

1. Empirically designed masonry, glass unit masonry or masonry veneer designed in accordance with Clause 22.9, 22.10 or Part 15, respectively, where they are part of a structure classified as Risk Category I, II or III.

2. Masonry foundation walls constructed in accordance with Table 18.7.1.6.3(1), 18.7.1.6.3(2), 18.7.1.6.3(3) or 18.7.1.6.3(4).

3. Masonry fireplaces, masonry heaters or masonry chimneys installed or constructed in accordance with Clause 22.11, 22.12 or 22.13, respectively.

19.5.4.1 Empirically designed masonry, glass unit masonry and masonry veneer in Risk Category IV.

Special inspections and tests for empirically designed masonry, glass unit masonry or masonry veneer designed in accordance with Clause 22.9, 22.10 or Part 15, respectively, where they are part of a structure classified as Risk Category IV shall be performed in accordance with TMS 402, Level B Quality Assurance.

19.5.4.2 Vertical masonry foundation elements.

Special inspections and tests of vertical masonry foundation elements shall be performed in accordance with Clause 19.5.4.

19.5.5 Wood construction.

Special inspections of prefabricated wood structural elements and assemblies shall be in accordance with Clause 19.4.2.5. Special inspections of site-built assemblies shall be in accordance with this clause.

19.5.5.1 High-load diaphragms.

High-load diaphragms designed in accordance with Clause 24.6.2 shall be installed with special inspections as indicated in Clause 19.4.2. The special inspector shall inspect the wood structural panel sheathing to ascertain whether it is of the grade and thickness shown on the approved construction documents. Additionally, the special inspector must verify the nominal size of framing members at adjoining panel edges, the nail or staple diameter and length, the number of fastener lines and that the spacing between fasteners in each line and at edge margins agrees with the approved construction documents.

19.5.6 Soils.

Special inspections and tests of existing site soil conditions, fill placement and load-bearing requirements shall be performed in accordance with this clause and Table 19.5.6. The approved geotechnical report and the construction documents prepared by the registered design professionals shall be used to determine compliance. During fill placement, the special inspector shall verify that proper materials and procedures are used in accordance with the provisions of the approved geotechnical report.

Exception: Where Clause 18.3 does not require reporting of materials and procedures for fill placement, the special inspector shall verify that the in-place dry density of the compacted fill is not less than 90 percent of the maximum dry density at optimum moisture content determined in accordance with ASTM D1557.

**TABLE 19.5.6**
REQUIRED SPECIAL INSPECTIONS AND TESTS OF SOILS

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTINUOUS SPECIAL INSPECTION</th>
<th>PERIODIC SPECIAL INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity.</td>
<td>—</td>
<td>X</td>
</tr>
<tr>
<td>2. Verify excavations are extended to proper depth and have reached proper material.</td>
<td>—</td>
<td>X</td>
</tr>
<tr>
<td>3. Perform classification and testing of compacted fill materials.</td>
<td>—</td>
<td>X</td>
</tr>
<tr>
<td>4. Verify use of proper materials, densities and lift thicknesses during placement and compaction of compacted fill.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>5. Prior to placement of compacted fill, inspect subgrade and verify that site has been prepared properly.</td>
<td>—</td>
<td>X</td>
</tr>
</tbody>
</table>

19.5.7 Driven deep foundations.

Special inspections and tests shall be performed during installation of driven deep foundation elements as specified in Table 19.5.7. The approved geotechnical report and the construction documents prepared by the registered design professionals shall be used to determine compliance.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTINUOUS SPECIAL INSPECTION</th>
<th>PERIODIC SPECIAL INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Verify element materials, sizes and lengths comply with the requirements.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>2. Determine capacities of test elements and conduct additional load tests, as required.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>3. Inspect driving operations and maintain complete and accurate records for each element.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>4. Verify placement locations and plumbness, confirm type and size of hammer, record number of blows per foot of penetration, determine required penetrations to achieve design capacity, record tip and butt elevations and document any damage to foundation element.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>5. For steel elements, perform additional special inspections in accordance with Clause 19.5.2.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>6. For concrete elements and concrete-filled elements, perform tests and additional special inspections in accordance with Clause 19.5.3.</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>7. For specialty elements, perform additional inspections as determined by the registered design professional in responsible charge.</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
19.5.8 Cast-in-place deep foundations.
Special inspections and tests shall be performed during installation of cast-in-place deep foundation elements as specified in Table 19.5.8. The approved geotechnical report and the construction documents prepared by the registered design professionals shall be used to determine compliance.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CONTINUOUS SPECIAL INSPECTION</th>
<th>PERIODIC SPECIAL INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inspect drilling operations and maintain complete and accurate records for each element.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>2. Verify placement locations and plumbness, confirm element diameters, bell diameters (if applicable), lengths, embedment into bedrock (if applicable) and adequate end-bearing strata capacity. Record concrete or grout volumes.</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>3. For concrete elements, perform tests and additional special inspections in accordance with Clause 19.5.3.</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

19.5.9 Helical pile foundations.
Continuous special inspections shall be performed during installation of helical pile foundations. The information recorded shall include installation equipment used, pile dimensions, tip elevations, final depth, final installation torque and other pertinent installation data as required by the registered design professional in responsible charge. The approved geotechnical report and the construction documents prepared by the registered design professional shall be used to determine compliance.

19.5.10 Fabricated items.
Special inspections of fabricated items shall be performed in accordance with Clause 19.4.2.5.

19.5.11 Special inspections for seismic resistance.
Special inspections for seismic resistance shall be required as specified in Clauses 19.5.11.1 through 19.5.11.9, unless exempted by the exceptions of Clause 19.4.2.

Exception: The special inspections specified in Clauses 19.5.11.1 through 19.5.11.9 are not required for structures designed and constructed in accordance with one of the following:

1. The structure consists of light-frame construction; the design spectral response acceleration at short periods, SDS, as determined in this Code, does not exceed 0.5; and the building height of the structure does not exceed 10 668 mm (35 feet).

2. The seismic force-resisting system of the structure consists of reinforced masonry or reinforced concrete; the design spectral response acceleration at short periods, SDS, as determined in this Code, does not exceed 0.5; and the building height of the structure does not exceed 7620 mm (25 feet).

3. The structure is a detached one- or two-family dwelling not exceeding two stories above grade plane and does not have any of the following horizontal or
vertical irregularities in accordance with Clause 12.3 of ASCE 7:

3.1. Torsional or extreme torsional irregularity.

3.2. Nonparallel systems irregularity.

3.3. Stiffness-soft storey or stiffness-extreme soft storey irregularity.

3.4. Discontinuity in lateral strength-weak storey irregularity.

19.5.11.1 Structural steel.
Special inspections for seismic resistance shall be in accordance with Clause 19.5.11.1.1 or 19.5.11.1.2, as applicable.

19.5.11.1.1 Seismic force-resisting systems.
Special inspections of structural steel in the seismic force-resisting systems in buildings and structures assigned to Seismic Design Zones shall be performed in accordance with the quality assurance requirements of ISO/IEC 17023.

Exceptions:

1. In buildings and structures assigned to Seismic Design Category B or C, special inspections of structural steel elements are not required for seismic force-resisting systems with a response modification coefficient, R, of 3 or less.

2. In structures assigned to Seismic Design Category D, E, or F, special inspections of structural steel elements are not required for seismic force-resisting systems where design and detailing other than AISC 341 is permitted by ASCE 7, Table 15.4-1. Special inspection shall be in accordance with the applicable referenced standard listed in ASCE 7, Table 15.4-1.

19.5.12.2 Structural wood.
For the seismic force-resisting systems of structures assigned to Seismic Design Category C, D, E or F:

1. Continuous special inspection shall be required during field gluing operations of elements of the seismic force-resisting system.

2. Periodic special inspection shall be required for nailing, bolting, anchoring and other fastening of elements of the seismic force-resisting system, including wood shear walls, wood diaphragms, drag struts, braces, shear panels and hold-downs.

Exception: Special inspections are not required for wood shear walls, shear panels and
diaphragms, including nailing, bolting, anchoring and other fastening to other elements of the seismic force-resisting system, where the fastener spacing of the sheathing is more than 102 mm (4 inches) on center.

19.5.11.3 Cold-formed steel light-frame construction.

For the seismic force-resisting systems of structures assigned to Seismic Design Category C, D, E or F, periodic special inspection shall be required for both:

1. Welding operations of elements of the seismic force-resisting system.

2. Screw attachment, bolting, anchoring and other fastening of elements of the seismic force-resisting system, including shear walls, braces, diaphragms, collectors (drag struts) and hold-downs.

Exception: Special inspections are not required for cold-formed steel light-frame shear walls and diaphragms, including screw installation, bolting, anchoring and other fastening to components of the seismic force-resisting system, where either of the following applies:

1. The sheathing is gypsum board or fibreboard.

2. The sheathing is wood structural panel or steel sheets on only one side of the shear wall, shear panel or diaphragm assembly and the fastener spacing of the sheathing is more than 102 mm (4 inches) on centre.

19.5.11.4 Designated seismic systems.

For structures assigned to Seismic Design Category C, D, E or F, the special inspector shall examine designated seismic systems requiring seismic qualification in accordance with Clause 13.2.2 of ASCE 7 and verify that the label, anchorage and mounting conform to the certificate of compliance.

19.5.11.5 Architectural components.

Periodic special inspection is required for the erection and fastening of exterior cladding, interior and exterior nonbearing walls and interior and exterior veneer in structures assigned to Seismic Design Category D, E or F.

Exception: Periodic special inspection is not required for the following:

1. Exterior cladding, interior and exterior nonbearing walls and interior and exterior veneer 9144 mm (30 feet) or less in height above grade or walking surface.

2. Exterior cladding and interior and exterior veneer weighing 24.5 N/m² (5 psf) or less.

3. Interior nonbearing walls weighing 73.5 N/m² (15 psf) or less.

19.5.11.5.1 Access floors.

Periodic special inspection is required for the anchorage of access floors in structures assigned to Seismic Design Category D, E or F.

19.5.11.6 Plumbing, mechanical and electrical components.

Periodic special inspection of plumbing, mechanical and electrical components shall be required for the following:

1. Anchorage of electrical equipment for emergency and standby power systems in structures assigned to Seismic Design Zones 2 and 3.

2. Anchorage of other electrical equipment in structures assigned to Seismic Design Zone 3.

3. Installation and anchorage of piping systems designed to carry hazardous materials and their associated mechanical units in structures assigned to Seismic Design Zones 2 and 3.
4. Installation and anchorage of ductwork designed to carry hazardous materials in structures assigned to Seismic Design Zones 2 and 3.

5. Installation and anchorage of vibration isolation systems in structures assigned to Seismic Design Zones 2 and 3 where the approved construction documents require a nominal clearance of 6.4 mm (1/4 inch) or less between the equipment support frame and restraint.

6. Installation of mechanical and electrical equipment, including duct work, piping systems and their structural supports, where automatic fire sprinkler systems are installed in structures assigned to Seismic Design Zones 2 and 3 to verify one of the following:

6.1. Minimum clearances have been provided as required by Clause 13.2.3 ASCE/SEI 7.

6.2. A nominal clearance of not less than 76 mm (3 inches) has been be provided between fire protection sprinkler system drops and sprigs and: structural members not used collectively or independently to support the sprinklers; equipment attached to the building structure; and other systems’ piping.

Where flexible sprinkler hose fittings are used, special inspection of minimum clearances is not required.

19.5.11.7 Storage racks.

Periodic special inspection is required for the anchorage of storage racks that are 2438 mm (8 feet) or greater in height in structures assigned to Seismic Design Category D, E or F.

19.5.11.8 Seismic isolation systems.

Periodic special inspection shall be provided for seismic isolation systems in seismically isolated structures assigned to Seismic Design Category B, C, D, E or F during the fabrication and installation of isolator units and energy dissipation devices.

19.5.11.9 Cold-formed steel special bolted moment frames.

Periodic special inspection shall be provided for the installation of cold-formed steel special bolted moment frames in the seismic force-resisting systems of structures assigned to Seismic Design Category D, E or F.

19.5.12 Testing for seismic resistance.

Testing for seismic resistance shall be required as specified in Clauses 19.5.13.1 through 19.5.13.4, unless exempted from special inspections by the exceptions of Clause 19.4.2.

19.5.12.1 Structural steel.

Nondestructive testing for seismic resistance shall be in accordance with Clause 19.5.12.1.1 or 19.5.12.1.2, as applicable.

19.5.12.1.1 Seismic force-resisting systems.

Nondestructive testing of structural steel in the seismic force-resistant systems in buildings and structures assigned to Seismic Design Zones 1, 2 and 3 shall be performed in accordance with the quality assurance requirements of ISO/IEC 17023.

Exceptions:

1. In buildings and structures assigned to Seismic Design Zones 1 and 2 nondestructive testing is not required for structural steel seismic force-resisting systems where the response modification coefficient, R, designated for “Steel systems not specifically detailed for seismic resistance, excluding cantilever column systems” in ASCE 7, Table 12.2-1, has been used for design and detailing.

2. In structures assigned to Seismic Design Zone 3 nondestructive testing is not required for structural steel seismic force-resisting systems where design and detailing in accordance with AISC...
360 is permitted by ASCE 7, Table 15.4-1.

19.5.12.1.2 Structural steel elements.

Nondestructive testing of structural steel elements in the seismic force-resisting systems of buildings and structures assigned to Seismic Design Zone 1, 2 and 3 other than those covered in Clause 19.5.13.1.1, including struts, collectors, chords and foundation elements, shall be performed in accordance with the quality assurance requirements of AISC 341.

Exceptions:

1. In buildings and structures assigned to Seismic Design Zones 1 and 2, nondestructive testing of structural steel elements is not required for seismic force-resisting systems with a response modification coefficient, R, of 3 or less.

2. In structures assigned to Seismic Design Zone 3, nondestructive testing of structural steel elements is not required for seismic force-resisting systems where design and detailing other than AISC 341 is permitted by ASCE 7, Table 15.4-1. Nondestructive testing of structural steel elements shall be in accordance with the applicable standard

19.5.12.2 Nonstructural components.

For structures assigned to Seismic Design Zones 1, 2 and 3, where the requirements of Clause 13.2.1 of ASCE 7 for nonstructural components, supports or attachments are met by seismic qualification as specified in Item 2 therein, the registered design professional shall specify on the approved construction documents the requirements for seismic qualification by analysis, testing or experience data. Certificates of compliance for the seismic qualification shall be submitted to the Head of the works department as specified in Clause 19.4.5.

19.5.13 Sprayed fire-resistant materials.

Special inspections and tests of sprayed fire-resistant materials applied to floor, roof and wall assemblies and structural members shall be performed in accordance with Clauses 19.5.13.1 through 19.5.13.6. Special inspections shall be based on the fire-resistance design as designated in the approved construction documents. The tests set forth in this clause shall be based on samplings from specific floor, roof and wall assemblies and structural members. Special inspections and tests shall be performed after the rough installation of electrical, automatic sprinkler, mechanical and plumbing systems and suspension systems for ceilings, where applicable.

19.5.13.1 Physical and visual tests.

The special inspections and tests shall include the following to demonstrate compliance with the listing and the fire-resistance rating:

1. Condition of substrates.
2. Thickness of application.
3. Density in pounds per cubic foot (kg/m3).
5. Condition of finished application.
19.5.13.2 Structural member surface conditions.

The surfaces shall be prepared in accordance with the approved fire-resistance design and the written instructions of approved manufacturers. The prepared surface of structural members to be sprayed shall be inspected by the special inspector before the application of the sprayed fire-resistant material.

19.5.13.3 Application.

The substrate shall have a minimum ambient temperature before and after application as specified in the written instructions of approved manufacturers. The area for application shall be ventilated during and after application as required by the written instructions of approved manufacturers.

19.5.13.4 Thickness.

Not more than 10 percent of the thickness measurements of the sprayed fire-resistant materials applied to floor, roof and wall assemblies and structural members shall be less than the thickness required by the approved fire-resistance design, and none shall be less than the minimum allowable thickness required by Clause 19.5.13.4.1.

19.5.13.4.1 Minimum allowable thickness.

For design thicknesses 25 mm (1 inch) or greater, the minimum allowable individual thickness shall be the design thickness minus 6.4 mm (1/4 inch). For design thicknesses less than 25 mm (1 inch), the minimum allowable individual thickness shall be the design thickness minus 25 percent. Thickness shall be determined in accordance with ASTM E605. Samples of the sprayed fire-resistant materials shall be selected in accordance with Clauses 19.5.13.4.2 and 19.5.13.4.3.

19.5.13.4.2 Floor, roof and wall assemblies.

The thickness of the sprayed fire-resistant material applied to floor, roof and wall assemblies shall be determined in accordance with ASTM E605, making not less than four measurements for each 93 m² (1,000 square feet) of the sprayed area, or portion thereof, in each storey.

19.5.13.4.3 Cellular decks.

Thickness measurements shall be selected from a square area, 305 mm by 305 mm (12 inches by 12 inches) in size. Not fewer than four measurements shall be made, located symmetrically within the square area.

19.5.13.4.4 Fluted decks.

Thickness measurements shall be selected from a square area, 305 mm by 305 mm (12 inches by 12 inches) in size. Not fewer than four measurements shall be made, located symmetrically within the square area, including one each of the following: valley, crest and sides. The average of the measurements shall be reported.

19.5.13.4.5 Structural members.

The thickness of the sprayed fire-resistant material applied to structural members shall be determined in accordance with ASTM E605. Thickness testing shall be performed on not less than 25 percent of the structural members on each floor.

19.5.13.4.6 Beams and girders.

At beams and girders thickness measurements shall be made at nine locations around the beam or girder at each end of a 305 mm (12-inch) length.

19.5.13.4.7 Joists and trusses.

At joists and trusses, thickness measurements shall be made at seven locations around the joist or truss at each end of a 305 mm (12-inch) length.

684
19.5.13.4.8 Wide-flanged columns.

At wide-flanged columns, thickness measurements shall be made at 12 locations around the column at each end of a 305 mm (12-inch) length.

19.5.13.4.9 Hollow structural clause and pipe columns.

At hollow structural clause and pipe columns, thickness measurements shall be made at not fewer than four locations around the column at each end of a 305 mm (12-inch) length.

19.5.13.5 Density.

The density of the sprayed fire-resistant material shall be not less than the density specified in the approved fire-resistance design. Density of the sprayed fire-resistant material shall be determined in accordance with ASTM E605. The test samples for determining the density of the sprayed fire-resistant materials shall be selected as follows:

1. From each floor, roof and wall assembly at the rate of not less than one sample for every 232 m² (2,500 square feet) or portion thereof of the sprayed area in each storey.

2. From beams, girders, trusses, columns and other structural members at the rate of not less than one sample for each type of structural member for each 232 m² (2,500 square feet) of floor area or portion thereof in each storey.

19.5.13.6 Bond strength.

The cohesive/adhesive bond strength of the cured sprayed fire-resistant material applied to floor, roof and wall assemblies and structural members shall be not less than 7.18 kN/m² (150 pounds per square foot (psf)). The cohesive/adhesive bond strength shall be determined in accordance with the field test specified in ASTM E736 by testing in-place samples of the sprayed fire-resistant material selected in accordance with Clauses 19.5.13.6.1 through 19.5.13.6.3.

19.5.13.6.1 Floor, roof and wall assemblies.

The test samples for determining the cohesive/adhesive bond strength of the sprayed fire-resistant materials shall be selected from each floor, roof and wall assembly at the rate of not less than one sample for every 232 m² (2,500 square feet) of the sprayed area, or portion thereof, in each storey.

19.5.13.6.2 Structural members.

The test samples for determining the cohesive/adhesive bond strength of the sprayed fire-resistant materials shall be selected from beams, girders, trusses, columns and other structural members at the rate of not less than one sample for each type of structural member for each 232 m² (2,500 square feet) of floor area or portion thereof in each storey.

19.5.13.6.3 Primer, paint and encapsulant bond tests.

Bond tests to qualify a primer, paint or encapsulant shall be conducted where the sprayed fire-resistant material is applied to a primed, painted or encapsulated surface for which acceptable bond-strength performance between these coatings and the fire-resistant material has not been determined. A bonding agent approved by the SFRM manufacturer shall be applied to a primed, painted or encapsulated surface where the bond strengths are found to be less than required values.

19.5.14 Mastic and intumescent fire-resistant coatings.

Special inspections and tests for mastic and intumescent fire-resistant coatings applied to structural elements and decks shall be performed in accordance with ASTM E 119. Special inspections and tests shall be based on the fire-resistance design as designated in the approved construction documents.
19.5.15 Exterior insulation and finish systems (EIFS).

Special inspections shall be required for all EIFS applications.

Exceptions:

1. Special inspections shall not be required for EIFS applications installed over a water-resistive barrier with a means of draining moisture to the exterior.

2. Special inspections shall not be required for EIFS applications installed over masonry or concrete walls.

19.5.15.1 Water-resistive barrier coating.

A water-resistive barrier coating complying with ASTM E2570 requires special inspection of the water-resistive barrier coating where installed over a sheathing substrate.

19.5.16 Fire-resistant penetrations and joints.

In high-rise buildings or in buildings assigned to Risk Category III or IV, special inspections for through-penetrations, membrane penetration firestops, fire-resistant joint systems and perimeter fire barrier systems that are tested and listed in accordance with Clauses 8.14.4.1.2, 8.14.5.1.2, 8.15.3 and 8.15.4 shall be in accordance with Clause 19.5.16.1 or 19.5.17.2.

19.5.16.1 Penetration firestops.

Inspections of penetration firestop systems that are tested and listed in accordance with Clauses 8.14.4.1.2 and 8.14.5.1.2 shall be conducted by an approved agency in accordance with ASTM E2174.

19.5.16.2 Fire-resistant joint systems.

Inspection of fire-resistant joint systems that are tested and listed in accordance with Clauses 8.15.3 and 8.15.4 shall be conducted by an approved agency in accordance with ASTM E2393.

19.5.17 Testing for smoke control.

Smoke control systems shall be tested by a special inspector.

19.5.17.1 Testing scope.

The test scope shall be as follows:

1. During erection of ductwork and prior to concealment for the purposes of leakage testing and recording of device location.

2. Prior to occupancy and after sufficient completion for the purposes of pressure difference testing, flow measurements and detection and control verification.

19.5.17.2 Qualifications.

Approved agencies for smoke control testing shall have expertise in fire protection engineering and building services engineering.

19.6 DESIGN STRENGTHS OF MATERIALS

19.6.1 Conformance to standards.

The design strengths and permissible stresses of any structural material that are identified by a manufacturer’s designation as to manufacture and grade by mill tests, or the strength and stress grade is otherwise confirmed to the satisfaction of the Head of the works department, shall conform to the specifications and methods of design of accepted engineering practice or the approved rules in the absence of applicable standards.

19.6.2 New materials.

For materials that are not specifically provided for in this Code, the design strengths and
permissible stresses shall be established by tests as provided for in Clause 19.7.

19.7 ALTERNATIVE TEST PROCEDURE

19.7.1 General.

In the absence of approved rules or other approved standards, the Head of the works department shall make, or cause to be made, the necessary tests and investigations; or the Head of the works department shall accept duly authenticated reports from approved agencies in respect to the quality and manner of use of new materials or assemblies as provided for in this Code. The cost of all tests and other investigations required under the provisions of this Code shall be borne by the owner or the owner's authorized agent.

19.8 IN-SITU LOAD TESTS

19.8.1 General.

Whenever there is a reasonable doubt as to the stability or load-bearing capacity of a completed building, structure or portion thereof for the expected loads, an engineering assessment shall be required. The engineering assessment shall involve either a structural analysis or an in-situ load test, or both. The structural analysis shall be based on actual material properties and other as-built conditions that affect stability or load-bearing capacity, and shall be conducted in accordance with the applicable design standard. The in-situ load tests shall be conducted in accordance with Clause 19.8.2. If the building, structure or portion thereof is found to have inadequate stability or load-bearing capacity for the expected loads, modifications to ensure structural adequacy or the removal of the inadequate construction shall be required.

19.8.2 In-situ load tests.

In-situ load tests shall be conducted in accordance with Clause 19.8.2.1 or 19.8.2.2 and shall be supervised by a registered design professional. The test shall simulate the applicable loading conditions specified in Part 17 as necessary to address the concerns regarding structural stability of the building, structure or portion thereof.

19.8.2.1 Load test procedure specified.

Where a referenced material standard contains an applicable load test procedure and acceptance criteria, the test procedure and acceptance criteria in the standard shall apply. In the absence of specific load factors or acceptance criteria, the load factors and acceptance criteria in Clause 19.8.2.2 shall apply.

19.8.2.2 Load test procedure not specified.

In the absence of applicable load test procedures contained within a material standard referenced by this Code or acceptance criteria for a specific material or method of construction, such existing structure shall be subjected to an approved test procedure developed by a registered design professional that simulates applicable loading and deformation conditions. For components that are not a part of the seismic force-resisting system, at a minimum the test load shall be equal to the specified factored design loads. For materials such as wood that have strengths that are dependent on load duration, the test load shall be adjusted to account for the difference in load duration of the test compared to the expected duration of the design loads being considered. For statically loaded components, the test load shall be left in place for a period of 24 hours. For components that carry dynamic loads (for example, machine supports or fall arrest anchors), the load shall be left in place for a period consistent with the component’s actual function. The structure shall be considered to have successfully met the test requirements where the following criteria are satisfied:

1. Under the design load, the deflection shall not exceed the limitations specified in this Code.

2. Within 24 hours after removal of the test load, the structure shall have recovered not less than 75 percent of the maximum deflection.
3. During and immediately after the test, the structure shall not show evidence of failure.

19.9 PRECONSTRUCTION LOAD TESTS

19.9.1 General.

Where proposed construction is not capable of being designed by approved engineering analysis, or where proposed construction design method does not comply with the applicable material design standard, the system of construction or the structural unit and the connections shall be subjected to the tests prescribed in Clause 19.9. The Head of the works department shall accept certified reports of such tests conducted by an approved testing agency, provided that such tests meet the requirements of this Code and approved procedures.

19.9.2 Load test procedures specified.

Where specific load test procedures, load factors and acceptance criteria are included in the applicable referenced standards, such test procedures, load factors and acceptance criteria shall apply. In the absence of specific test procedures, load factors or acceptance criteria, the corresponding provisions in Clause 19.9.3 shall apply.

19.9.3 Load test procedures not specified.

Where load test procedures are not specified in the applicable referenced standards, the load-bearing and deformation capacity of structural components and assemblies shall be determined on the basis of a test procedure developed by a registered design professional that simulates applicable loading and deformation conditions. For components and assemblies that are not a part of the seismic force-resisting system, the test shall be as specified in Clause 19.9.3.1. Load tests shall simulate the applicable loading conditions specified in this Code.

19.9.3.1 Test procedure.

The test assembly shall be subjected to an increasing superimposed load equal to not less than two times the superimposed design load. The test load shall be left in place for a period of 24 hours. The tested assembly shall be considered to have successfully met the test requirements if the assembly recovers not less than 75 percent of the maximum deflection within 24 hours after the removal of the test load. The test assembly shall then be reloaded and subjected to an increasing superimposed load until either structural failure occurs or the superimposed load is equal to two and one-half times the load at which the deflection limitations specified in Clause 19.9.3.2 were reached, or the load is equal to two and one-half times the superimposed design load. In the case of structural components and assemblies for which deflection limitations are not specified in Clause 19.9.3.2, the test specimen shall be subjected to an increasing superimposed load until structural failure occurs or the load is equal to two and one-half times the desired superimposed design load. The allowable superimposed design load shall be taken as the lesser of:

1. The load at the deflection limitation given in Clause 19.9.3.2.

2. The failure load divided by 2.5.

3. The maximum load applied divided by 2.5.

19.9.3.2 Deflection.

The deflection of structural members under the design load shall not exceed the limitations in this Code.

19.9.4 Wall and partition assemblies.

Load-bearing wall and partition assemblies shall sustain the test load both with and without window framing. The test load shall include all design load components. Wall and partition assemblies shall be tested both with and without door and window framing.
19.9.5 Exterior window and door assemblies.

The design pressure rating of exterior windows and doors in buildings shall be determined in accordance with Clause 19.9.5.1 or 19.9.5.2. For exterior windows and doors tested in accordance with Clauses 19.9.5.1 or 19.9.5.2, required design wind pressures determined from ASCE 7 shall be permitted to be converted to allowable stress design by multiplying by 0.6.

**Exception:** Structural wind load design pressures for window units smaller than the size tested in accordance with Clause 19.9.5.1 or 19.9.5.2 shall be permitted to be higher than the design value of the tested unit provided such higher pressures are determined by accepted engineering analysis. Components of the small unit shall be the same as the tested unit. Where such calculated design pressures are used, they shall be validated by an additional test of the window unit having the highest allowable design pressure.

19.9.5.1 Exterior windows and doors.

Exterior windows and sliding doors shall be tested and labelled as conforming to GS 194. The label shall state the name of the manufacturer, the approved labelling agency and the product designation. Exterior side-hinged doors shall be tested and labelled. Products tested and labeled as in this clause shall not be subject to the requirements of Clauses 25.3.2 and 25.3.3.

19.9.5.2 Exterior windows and door assemblies not provided for in Clause 19.9.5.1.

Exterior window and door assemblies shall be tested in accordance with ASTM E330. Structural performance of garage doors and rolling doors shall be determined in accordance with ASTM E330 and shall meet the acceptance criteria of this Code. Exterior window and door assemblies containing glass shall comply with Clause 25.3. The design pressure for testing shall be calculated in accordance with Part 17. Each assembly shall be tested for 10 seconds at a load equal to 1.5 times the design pressure.

19.9.6 Skylights and sloped glazing.

Skylights and sloped glazing shall comply with the requirements of Part 25.

19.9.7 Test specimens.

Test specimens and construction shall be representative of the materials, workmanship and details normally used in practice. The properties of the materials used to construct the test assembly shall be determined on the basis of tests on samples taken from the load assembly or on representative samples of the materials used to construct the load test assembly. Required tests shall be conducted or witnessed by an approved agency.
PART 20: CONCRETE WORKS

User notes:
About this part: Part 20 provides minimum accepted practices for the design and construction of buildings and structural components using concrete—both plain and reinforced. Part 20 relies primarily on the reference to the Ghana High way Authority, Building Code Requirements for Structural Concrete. Structural concrete must be designed and constructed to comply with this Code and all listed standards. There are also specific provisions addressing concrete slabs and shotcrete.

20.1 GENERAL

20.1.1 Scope

This clause covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the Permanent Works.

20.2 MATERIALS FOR CONCRETE

20.2.1 General

The Owner or Owner’s Authorised Agent shall submit to the Head of works full details of all materials that he proposes to use for making concrete. No concrete shall be placed in the Works until the Head of works has approved the materials of which it is composed. Approved materials shall not thereafter be altered or substituted by other materials without the consent of the Head of works.

20.2.2 Cement

Cement shall be Portland or Rapid-hardening cement, and shall comply with the requirements of GS 1118 cement standard. Cement shall be classified according to strength class and constituents and the cement classification shall be clearly indicated when delivered to site.

Sulphate resistant cement shall only be used if specified by the Head of works and all details of the cement shall be submitted to the Head of works before use.

The extenders shall meet the requirements as set in the standards listed. Extenders used in a concrete mixture are taken into account as part of the cement content for calculating the minimum cement content or the water/cement ratio: the properties of this blended cement shall be established according to the requirements of EN 196.

The strength class of all cement is determined according to BS EN 196-1. The standard strength of cement is the compressive strength at 28 days. The standard and early cement strength requirements of GS 1118 are listed in Table 20.1. The early strength of cement is determined after either 2 days or 7 days and the early strength can be normal (indicated by N) or high (indicated by R).
Table 20.1: GS 1118 Cement strength requirements

<table>
<thead>
<tr>
<th>Strength Class</th>
<th>Compressive strength requirement (MPa)</th>
<th>Initial setting time (min)</th>
<th>Lower level limit values for single results</th>
<th>Early strength</th>
<th>Standard strength</th>
<th>Initial setting time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early strength</td>
<td>Standard strength</td>
<td>2 days</td>
<td>7 days</td>
<td>28 days</td>
<td>7 days</td>
</tr>
<tr>
<td>32.5 N</td>
<td>≥ 16.0</td>
<td>≥ 32.5 ≤ 52.5</td>
<td>≥ 75</td>
<td>14.0</td>
<td>30.0</td>
<td>60</td>
</tr>
<tr>
<td>32.5 R</td>
<td>≥ 10.0</td>
<td></td>
<td>8.0</td>
<td>30.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42.5 N</td>
<td>≥ 10.0</td>
<td>≥ 42.5 ≤ 62.5</td>
<td>≥ 60</td>
<td>8.0</td>
<td>40.0</td>
<td>50</td>
</tr>
<tr>
<td>42.5 R</td>
<td>≥ 20.0</td>
<td></td>
<td>18.0</td>
<td>40.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52.5 N</td>
<td>≥ 20.0</td>
<td>≥ 52.5</td>
<td>≥ 45</td>
<td>18.0</td>
<td>50.0</td>
<td>40</td>
</tr>
<tr>
<td>52.5 R</td>
<td>≥ 30.0</td>
<td></td>
<td>28.0</td>
<td>50.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cement with strength classes lower than 32.5 shall not be used in concrete.

20.2.3 Aggregate

Both coarse aggregate (stone) and fine aggregate (sand) shall be clean, hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with BS EN 12620. The aggregate shall not contain iron pyrites or iron oxides. It shall not contain mica, shale, coal or other laminar, soft or porous materials or organic matter unless the Owner or Owner’s Authorised Agent can show by comparative tests, on finished concrete that the presence of such materials does not adversely affect the properties of the concrete.

Where there is a danger of a particular combination of aggregate (particularly those containing amorphous and fine grained silica such as opal, tridymite, cristobalite and volcanic glasses in some quartzites, strain quartz, granites and metasediments) and cement giving rise to a harmful alkali-aggregate reaction, the particular combination shall be tested. When tested for potential alkali-silica reactivity in accordance with ASTM C 1260, C 227, C 295 and C 289, the aggregate shall be non-reactive.

All the material used as fine aggregate shall pass through a 4 mm sieve. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source.

The grading used in the initial mix designs shall be submitted to the Head of works and the grading of the fine aggregate used subsequently shall not deviate by more than the percentages indicated in Table 20.2 from the grading submitted. If the grading of the fine aggregate changes significantly, new mixes will have to be tested and approved for all classes of concrete.

Table 20.2: Tolerances on declared typical grading for fine aggregate (BS EN 12620)

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>Tolerance in percentage passing (% by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>±5</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>±10</td>
</tr>
<tr>
<td>0.250</td>
<td>±10</td>
</tr>
<tr>
<td>0.063</td>
<td>±3</td>
</tr>
</tbody>
</table>

The fine aggregate content passing a 63 micron sieve shall not exceed 3% for natural or crushed gravel sand or 15% for crushed rock sand.

The fineness modulus (FM) of the fine aggregate can be calculated as the sum of the cumulative percentages (by mass) retained on the following sieves (mm), expressed as a percentage:

$$FM = \frac{\sum_{(>4)+(>2)+(>1)+(>0.5)+(>0.25)+(>0.125)}}{100}$$
The FM of the fine aggregate shall not vary by more than \( \pm 0.2 \) from the approved modulus.

Coarse aggregate shall be supplied in the nominal sizes called for in the Special Specification and shall be graded in accordance with BS EN 12620 for each nominal size.

The proportion of clay, silt and other impurities passing a 63 micron sieve shall be not more than 1.0% by mass.

The total shell content of coarse aggregate shall not be more than the following:

- 40 mm nominal size and above: 2% of dry mass
- 20 mm nominal size: 5% of dry mass
- 10 mm nominal size: 15% of dry mass

Coarse aggregate shall have a 10% Fines test result of not less than 160 kN and the Wet/Dry ratio shall be at least 75%.

The Los Angeles Abrasion (LAA) value of the coarse aggregate shall not be more than 40%.

The Flakiness Index of the coarse aggregate when tested in accordance with EN 12620 shall be:

- For natural aggregate not more than 40
- For crushed aggregate not more than 35

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected by such variation.

The drying shrinkage of coarse aggregate shall not be greater than 0.075% when tested to BS EN 1367–4.

The aggregate shall not have a water absorption of more than 2.5% when tested according to ASTM C 127.

### 20.2.4 Water for concrete and mortar

Mixing water shall be clean and free from harmful matter such as detrimental concentrations of acids, alkalis, salts, sugar and other organic or chemical substances that could impair the durability and strength of the concrete or the imbedded steel. Water shall conform to BS EN 1008. For reinforced and prestressed concrete the chloride content of the mixing water shall not exceed 500 mg/l.

### 20.2.5 Admixtures

The use of the admixtures in concrete may be required under the Contract to promote special properties in the finished concrete or may be proposed by the Owner or Owner’s Authorised Agent to assist him in compliance with the Specification.

Admixtures shall not be used in concrete without the approval of the Head of works, who may require that the admixtures be tested to prove their suitability. Admixtures shall conform to BS EN 934-2 or ASTM C 494 and shall be of an approved brand and type.

Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by a mechanical batcher that is capable of dispensing the admixture in quantities accurate to within 5% of the required quantity.

Calcium chloride or admixtures based on chlorides shall not be used in concrete. The chloride ion content of any admixture shall not exceed 2% by mass of the admixture nor 0.03% by mass of the cement in the mix.

Accelerating and retarding admixtures shall be used only where an accelerated or retarded set has been specified.

The total amount of admixtures, if any, shall not exceed the maximum dosage recommended by the admixture producer and not exceed 50 g of admixture (as supplied) per kg cement unless the influence of the higher dosage on the performance and the durability of the concrete has been established to the satisfaction of the Head of works.
If the total quantity of liquid admixtures exceeds 3 ℓ/m³ of concrete, its water content shall be taken into account when calculating the water/cement ratio.

Where more than one admixture is used, the compatibility of the admixtures shall be checked in the initial tests.

In all cases the Owner or Owner’s Authorised Agent shall submit to the Head of works full details of the admixture he proposes to use and the manner in which he proposes to add it to the mix. The information provided shall include: -

(i) The typical dosage, the method of dosing and the detrimental effects of an excess or deficiency in the dosage.

(ii) The chemical names of the main active ingredients in the admixture.

(iii) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by mass of admixture.

(iv) Whether the admixture leads to the entrainment of air when used at the manufacturer’s recommended dosage and if so, the extent to which it does so.

(v) Details of previous uses of the admixture.

20.3 STORAGE OF MATERIALS

20.3.1 Cement

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer’s sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles in a manner that protects the cement from damage and deterioration.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it. Cement from broken bags shall not be used. Cement in bags shall be used in the order in which it is delivered.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation but shall not be stacked against an outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3 m in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks.

Cement that has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site and discarded in an approved location and manner in accordance with the Environmental Management Plan.

Cement that is stored on Site for longer than one month shall be retested at the rate of one set of tests as shown in this Code. The Specification for every 200 tonnes, and at monthly intervals thereafter.
20.3.2 Aggregates

Aggregates shall be delivered to Site in clean and suitable vehicles. Different types or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that contamination of the aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregates shall be arranged so that, as far as possible rapid drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

20.3.3 Storage capacity

The storage capacity and the quantity of material (whether it is water, cement or aggregates) stored shall be sufficient to ensure that no interruptions to the progress of the work will be caused by a lack of materials.

20.4 CONCRETE QUALITY

20.4.1 General

The concrete composition and the constituent materials for designed or prescribed concrete shall be chosen to satisfy the requirements specified for fresh and hardened concrete, including consistence, density, strength, durability and protection of embedded steel against corrosion, taking into account the production process and the intended method of execution of concrete works. Concrete shall comply with the requirements for strength of concrete or prescribed mix concrete as specified in this Code.

The total chloride content, expressed as chloride ion, arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as a percentage of the mass of cement in the mix:

(i) For prestressed concrete, steam cured concrete or concrete containing sulfate resisting or supersulfated cement: 0.05%.

(ii) For any other reinforced concrete: 0.2% in 95% of all test results provided no result is more than 0.4%.

The total sulfate content expressed as SO$_3$ of all the ingredients in a mix including cement, water and admixtures shall not exceed 0.4% by mass of the aggregate or 4.0% of the mass of cement in the mix, whichever is the lesser.

When determining conformity of chloride content in accordance with BS EN 206, the method for determining the chloride content of constituent materials shall be in accordance with the following tests methods:

- Cement, fly ash, GGBS, limestone fines, PFA, metakaolin: BS EN 196–21
- Aggregate: BS EN 1744–1
- Admixture: BS EN 480–10
- Water: BS EN 196–21

(Testing of water is not required if the water is from a potable supply.)

The total alkaline content (Na$_2$O - equivalent) of concrete shall be limited to 2.1 kg/m$^3$.

20.4.2 Strength concrete

The Owner or Owner’s Authorised Agent shall be responsible for the design of the concrete mix and for the proportions of the constituent materials necessary for producing concrete that complies with the requirements specified below for each class of concrete. The characteristic strength of structural concrete shall be determined from cubes or cylinders and the strength shall be one of the strength classes as indicated on the Drawings and listed in Table 20.3. Where the compressive strength is to be determined, it shall be expressed as $f_{c,\text{cube}}$ where determined using cubical specimens and $f_{c,\text{cyl}}$ where determined using cylindrical specimens, in accordance with BS EN 12390-3. The characteristic strength of the concrete shall be...
equal to or greater than the minimum characteristic compressive strength for the specified compressive strength class in Table 20.3.

The Owner or Owner’s Authorised Agent shall indicate whether the compressive strength is to be assessed on the basis of cube or cylinder tests in due time before delivery. If a different method is to be used, this shall be agreed between the Head of works and the Owner or Owner’s Authorised Agent.

Unless specified otherwise in the Special Specification, the compressive strength is determined on specimens tested at 28 days. For particular uses, it may be necessary to specify the compressive strength at ages earlier or later than 28 days (e.g. for massive structural elements) or after storage under special conditions (e.g. heat treatment).

### Table 20.3: Classes of concrete

<table>
<thead>
<tr>
<th>Class of concrete</th>
<th>Characteristic cylinder strength (N/mm²)</th>
<th>Characteristic cube strength (N/mm²)</th>
<th>Maximum water/cement ratio</th>
<th>Minimum cement content (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C20/25</td>
<td>20</td>
<td>25</td>
<td>0.7</td>
<td>0.65</td>
</tr>
<tr>
<td>C25/30</td>
<td>25</td>
<td>30</td>
<td>0.6</td>
<td>0.55</td>
</tr>
<tr>
<td>C30/37</td>
<td>30</td>
<td>37</td>
<td>0.55</td>
<td>0.5</td>
</tr>
<tr>
<td>C35/45</td>
<td>35</td>
<td>45</td>
<td>0.5</td>
<td>0.45</td>
</tr>
<tr>
<td>C40/50</td>
<td>40</td>
<td>50</td>
<td>0.45</td>
<td>0.4</td>
</tr>
<tr>
<td>C45/55</td>
<td>45</td>
<td>55</td>
<td>0.45</td>
<td>0.4</td>
</tr>
<tr>
<td>C50/60</td>
<td>50</td>
<td>60</td>
<td>0.45</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**NOTE:** Under water/cement ratio, column A applies to moderate and intermediate exposure, and column B to severe exposure.

The Owner or Owner’s Authorised Agent shall design all the concrete mixes called for on the Drawings, making use of the ingredients that have been approved by the Head of works for use in the Works and in compliance with the following requirements:

(i) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 125 micron size.

(ii) The cement content shall be such as to achieve the strengths required but in any case not less than the minimum necessary for impermeability and durability shown in Table 20.3.

(iii) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.

(iv) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than that shown in Table 20.3 taking due account of any water contained in the aggregates. The Owner or Owner’s Authorised Agent shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.

(v) The drying shrinkage determined in accordance with BS EN 12390 shall not be greater than 0.05%.

### 20.4.3 Trial mixes

At least six weeks before commencing placement of concrete in the Permanent Works, trial mixes shall be prepared by the Owner or Owner’s Authorised Agent for each class of concrete specified.

For each mix of concrete for which the Owner or Owner’s Authorised Agent has proposed a design, he shall prepare three separate batches of concrete using the materials that have been approved for use in the Works and the mixing plant that he proposes to use for the Works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the following action taken:

(i) The slump of the concrete shall be determined according to BS EN 12350-2. If
the consistency of the mix is such that no meaningful slump measurement can be taken, an alternative means of measurement shall be used as indicated in Clause 0.

(ii) Six test cubes or cylinders shall be cast for each age of concrete. In the case of concrete having a maximum aggregate size of 40 mm or less, 150 mm cubes or 150 diameter by 300 mm high cylinders shall be used. In the case of concrete containing 75 mm or larger aggregate, 200 mm cubes shall be used and aggregates larger than 63 mm shall be removed from the mixed concrete before casting the cubes.

(iii) Test samples shall be demoulded 24 hours after casting and cured in water at 27 ±2°C up to the time of testing.

(iv) Three samples from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.

(v) The density of all the samples shall be determined before the strength tests are carried out.

(vi) Samples shall be loaded according to BS EN 12390-3 in a press that meets the requirements set out in BS EN 12390-4.

The average strength of the nine samples tested at 28 days shall exceed the prescribed characteristic strength by not less than 4 N/mm². No individual strength result shall be more than 4 N/mm² less than the required characteristic strength.

The Owner or Owner’s Authorised Agent shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Head of works.

Based on the results of the tests on the trial mixes, the Owner or Owner’s Authorised Agent shall submit full details of his proposals for mix design to the Head of works, including the type and source of each ingredient, the proposed proportions of each mix and the results of the tests on the trial mixes.

If the Head of works does not agree to a proposed concrete mix for any reason, the Owner or Owner’s Authorised Agent shall amend his proposals and carry out further trial mixes. No mix shall be used without the written consent of the Head of works.

20.4.4 Nominal prescribed mix for non-structural concrete

The Owner or Owner’s Authorised Agent shall submit samples of every constituent of the concrete in accordance with the appropriate provisions in this Code for approval.

The nominal prescribed mixes for non-structural (NS) concrete are given in Table 20.4. The class of concrete is indicated by the mix; for example a class 1:3:6 concrete shall mean a concrete with a prescribed mix in a volume ratio of one part cement: three parts sand and six parts stone as well as the nominal cube compressive strength (eg, NS 10).

<table>
<thead>
<tr>
<th>Constituent or property</th>
<th>Mix 1: 4: 8</th>
<th>Mix 1: 3: 6</th>
<th>Mix 1: 2: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>NS 10</td>
<td>NS 15</td>
<td>NS 20</td>
</tr>
<tr>
<td>Cement (kg)</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Aggregate (m³)</td>
<td>0.41</td>
<td>0.31</td>
<td>0.21</td>
</tr>
<tr>
<td>Maximum water (ℓ)</td>
<td>46</td>
<td>35.5</td>
<td>28.5</td>
</tr>
<tr>
<td>Maximum water/cement</td>
<td>0.92</td>
<td>0.71</td>
<td>0.57</td>
</tr>
<tr>
<td>ratio (by mass)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 day Compressive</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Strength (MPa)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

20.4.5 Consistency and workability

The concrete shall be of suitable workability without the excessive use of water so that it can be readily compacted into the corners of the formwork and around the reinforcement, tendons and ducts without material segregating.

Where the consistence of concrete is to be determined, it shall be measured either by means of:

i. slump test conforming to BS EN 12350-2;
ii. Vebe test conforming to BS EN 12350-3;
iii. degree of compactability conforming to BS EN 12350-4;
iv. flow table test conforming to BS EN 12350-5;
v. specific methods to be agreed upon between the Head of works and the Owner or Owner’s Authorised Agent for concrete for special applications.

Due to the lack of sensitivity of the test methods beyond certain values of consistence, the above tests shall only be used on concrete with properties within the following limits:

i. slump between 10 mm and 210 mm;
ii. Vebe time between 30 and 5 seconds;
iii. degree of compactability between 1.04 and 1.46;
iv. flow diameter between 340 mm and 620 mm.

Where the consistency of concrete is to be determined, it shall be tested at the time of use of the concrete or in the case of ready-mixed concrete, at the time of delivery. If concrete is delivered in a truck mixer or agitating equipment, the consistence may be measured using a spot sample obtained from the initial discharge. The spot sample shall be taken after a discharge of approximately 0.3 m³ in accordance with BS EN 12350-1.

The consistency may be specified by a target value on the design drawings. For target values, the related tolerances are given in Table 20.5. If no specific target value is specified the Owner or Owner’s Authorised Agent shall produce concrete with a target slump of 75 mm. The Owner or Owner’s Authorised Agent may only produce concrete with a consistence outside the range specified, with the written approval of the Head of works.

### Table 20.5: Tolerances for target values of consistence according to BS EN 206.

<table>
<thead>
<tr>
<th>Slump</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target value</td>
<td>± 3</td>
</tr>
<tr>
<td>(mm)</td>
<td>± 2</td>
</tr>
<tr>
<td>≥ 100</td>
<td>± 1</td>
</tr>
<tr>
<td>Tolerance</td>
<td>± 0.10</td>
</tr>
<tr>
<td>(mm)</td>
<td>± 0.08</td>
</tr>
<tr>
<td>≤ 10</td>
<td>± 0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Degree of compactability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target value</td>
</tr>
<tr>
<td>(sec)</td>
</tr>
<tr>
<td>≥ 1.26</td>
</tr>
<tr>
<td>1.25 to 1.11</td>
</tr>
<tr>
<td>≤ 1.10</td>
</tr>
<tr>
<td>Tolerance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target value</td>
</tr>
<tr>
<td>(mm)</td>
</tr>
<tr>
<td>Tolerance</td>
</tr>
<tr>
<td>(mm)</td>
</tr>
</tbody>
</table>

#### 20.4.6 Bleeding

The concrete shall be so proportioned with suitable materials that bleeding is not excessive as assessed by the Head of works.

#### 20.4.7 Pumped concrete

Where pumping of concrete is approved by the Head of works, the concrete shall be so designed that suitable graded aggregate and admixtures are used to improve the pumpability of the mix.

The shrinkage capacity of the concrete to be pumped shall not be higher than that of ordinary concrete mixes.

#### 20.5 PLANT FOR CONCRETING OPERATIONS

The Owner or Owner’s Authorised Agent shall submit to the Head of works full details, including drawings, of all the plant that he proposes to use and the arrangements and procedures he proposes to follow, for batching, mixing, transporting, placing, compacting and finishing concrete, before such plant is ordered or delivered to Site.

Batching and mixing plants shall be modern and efficient equipment complying with the requirements of BS 1305 and capable of producing a uniform distribution of the ingredients throughout the mass. If the plant proposed by the Owner or Owner’s Authorised Agent does not fall within the scope of BS 1305, it shall have been tested in accordance with BS 3963 and shall have a mixing performance within the limits of Table 6 of BS 1305.
Immersion vibrators shall operate at a frequency of between 7,000 and 10,000 cycles per minute. The Owner or Owner’s Authorised Agent shall ensure that vibrators are operated at pressures and voltages not less then those recommended by the manufacturer in order that the compactive effort is not reduced.

20.6 MEASURING THE MATERIALS

20.6.1 General

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the required tolerance and checked against accurate masses and volumes when required by the Head of works.

The masses of cement and of each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of plus or minus 2% of the respective masses per batch approved by the Head of works.

The Owner or Owner’s Authorised Agent shall provide standard test masses at least equivalent to the maximum working load used on the most heavily loaded scale and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device. Tests shall be made by the Owner or Owner’s Authorised Agent at least once a week or at intervals to be determined by the Head of works and shall be carried out in his presence. For the purpose of carrying out these tests, there shall be easy access for personnel to the weigh hoppers. The Owner or Owner’s Authorised Agent shall furnish the Head of works with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

20.6.2 Cement

Where cement is supplied in standard bags, the bag shall be assumed to contain 50 kg. All cement taken from bulk containers or partly used bags shall be batched by mass, accurate to within 2% of the required mass.

The batching of cement in gauge boxes shall not be permitted. Volume batching shall be planned as to use full bags of cement.

20.6.3 Water

The mixing water for each batch shall be measured either by mass or by volume, accurate to 2% of the required quantity.

20.6.4 Aggregate

(a) Aggregate for strength concrete

All aggregate for strength concrete shall be measured separately by mass, accurate to 2% of the required mass. The aggregate storage bins shall be provided with drainage facilities arranged so that drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt removed.

(b) Aggregate for prescribed mix concrete

Aggregates for prescribed-mix concrete as specified in this Code may be measured separately by volume. Batching boxes for volume batching shall be filled without any tamping, ramming or consolidating of material other than that occurring naturally. Boxes shall be screened off level with their topmost edges.

Any adjustment to the volume shall be made by supplementary boxes of a suitable size being used. Adjustment of the volume of boxes by incomplete filling will not be permitted.

Fine aggregate shall be tested for bulking at the beginning and halfway through every concreting shift and adjustment shall be made to the batch volume to give the true volume required.

20.7 MIXING CONCRETE

20.7.1 General

Concrete shall be batched and mixed in one or more central plants unless the Head of works agrees to some other arrangement. Batching and mixing plants shall be modern and efficient...
equipment capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixers shall only be used with the prior approval of the Head of works.

All mixing operations shall be under the control of an experienced supervisor. Unless otherwise authorised, mixing shall be carried out in a mechanical mass batch-mixer of an approved type which will be capable of producing a uniform distribution of ingredients throughout the batch.

20.7.2 Charging the mixer

The sequence of charging the ingredients shall be subject to approval of the Head of works, and, unless otherwise instructed, the same mixing sequence of charging ingredients shall be maintained. The volume of mixed material by batch shall not exceed the volume recommended by the manufacturer of the mixer.

20.7.3 Mixing and discharging

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or pan.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Owner or Owner’s Authorised Agent by a method approved by the Head of works immediately before mixing begins each day and thereafter at least once per hour during concreting and for delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

After mixing for the required time, each batch shall be discharged completely from the mixer before any materials for the succeeding batch are introduced.

Mixers that have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed and thereafter the first batch of concrete through the mixers shall contain only half the normal quantity of coarse aggregate. This batch shall be mixed for one minute longer than the time applicable to a normal batch.

20.7.4 Maintaining and cleaning the mixer

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers shall be cleaned out before changing to another type of cement.

If the mixer has stopped running for a period in excess of 30 minutes, it shall be thoroughly cleaned out.

Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete shall be removed.

20.7.5 Standby mixer

When clauses are cast where it is important for the casting to continue without interruption, a standby mixer shall be held in readiness to run on 15 minutes notice should the stock mixer break down.

20.7.6 Ready mixed concrete

If the Owner or Owner’s Authorised Agent proposes to use ready mixed concrete he shall submit to the Head of works for his approval full details and test results of the concrete mixes. The Head of works may approve the use of ready mixed concrete provided that:

i. the proposed mixes, the material to be used and the method of storage and mixing comply with the requirements of the Specification; and

ii. adequate control is exercised during mixing.
Approval for the use of ready mixed concrete shall be withdrawn if the Head of works is not satisfied with the control of the materials being used and control during mixing.

20.7.7 Hand Mixed Concrete

Concrete for structural purposes shall not be mixed by hand. Where non-structural concrete is required, hand mixing may be carried out subject to the approval of the Head of works.

The mixing shall be done on a hard impermeable surface. The materials shall be turned over not less than three times dry, water shall then be sprayed on and the materials again turned over not less than three times in a wet condition and worked together until a mixture of uniform consistency is obtained.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.5 m$^3$ shall be mixed at one time. During windy weather efficient precautions shall be taken to prevent cement from being blown away during the process of gauging and mixing.

20.8 TRANSPORT OF CONCRETE

The concrete shall be discharged from the mixer and transported to the Works by means that shall prevent contamination, segregation or loss of ingredients and, which shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall not exceed 25 mm.

The time elapsing between mixing and placing a batch of concrete shall be as short as practicable and in no case longer than will permit completion of placing and compaction before the onset of initial set. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the Works.

The concrete shall be deposited as close as practicable in the final position to avoid rehandling or moving of the concrete horizontally by vibration.

Ready-mixed concrete shall be transported and delivered in accordance with BS EN 206.

20.9 PLACING OF CONCRETE

20.9.1 Consent for placing

Concrete shall not be placed until the Head of works's consent has been given in writing, and the Owner or Owner’s Authorised Agent shall give the Head of works at least one full working day's notice of his intention to place concrete. If concrete placing is not commenced within 24 hours of the Head of works's consent the Owner or Owner’s Authorised Agent shall again request consent as specified above.

Concreting operations shall only be carried out during daylight hours unless adequate lighting arrangements have been made and the lights are in working order by noon. Workmen shall not be allowed to work double shifts, and the Owner or Owner’s Authorised Agent shall provide a fresh team for night shifts.

All placing and compaction of concrete shall be carried out under the direct supervision of an experienced concrete supervisor.

Once the casting of concrete has begun, it shall be carried out in a continuous process between construction joints.

20.9.2 Time for placing

Concrete shall be placed within 60 minutes of mixing.

20.9.3 Preparation of surface to receive concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in this Code. Where specified or directed by the Head of works, excavated surfaces, shall be lined with an approved sheeting to provide a clean impervious layer. The lining material shall be of sufficient strength to provide a durable working surface, and to support the concrete and reinforcement without tearing. The joints of the material between strips shall have a 150 mm overlap, and the lining shall be held firmly in position by nails, pegs, etc. Polyethylene sheeting shall have a minimum thickness of
0.15 mm, and waterproof paper shall comply with BS 1521 Waterproof Building Paper, Class B, and shall have fibrous reinforcement.

Existing concrete surfaces shall be prepared as set out in this Code.

All excavations and other contact surfaces of an absorbent nature shall be damp but no standing water shall be permitted to remain on these surfaces. All formwork shall be clean on the inside.

If so required by the Head of works excavated surfaces against which concrete is to be placed shall receive a prior coating of mortar mixed in the proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete, it shall be well worked into all parts of the excavated surface and it shall be not less than 5 mm thick. Fissures that have been cleaned out shall be filled with mortar or with concrete as instructed by the Head of works.

The amount of mortar placed at any one time shall be so controlled that it does not dry out or set before being covered with concrete.

Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other suitable methods, so as to prevent the washing away of the freshly deposited concrete or any of its constituents. Any underdrains constructed for this purpose shall be fully grouted up when they are no longer required.

The Owner or Owner’s Authorised Agent shall take precautions to ensure that no cement or concrete is dropped into water courses. If required by the Environmental Management Plan, the Owner or Owner’s Authorised Agent shall monitor the pH and turbidity of water courses and bodies in the vicinity of construction to ensure that water quality levels are maintained.

20.9.4 Placing procedures

The concrete shall be deposited as near as possible to its final position. Where possible, concrete shall be deposited vertically into its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items, or formwork. When it is discharged above its place of final deposition, segregation shall be prevented by the use of chutes, downpipes, trunking, baffles or other appropriate devices.

Forms for walls, columns and other thin clauses of significant height shall be provided with openings or other devices that will limit the height through which the fresh concrete has to fall, and thereby prevent segregation and accumulation of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

In vertical elements such as walls or columns, concrete shall be brought up in layers of approximately uniform thicknesses parallel to the construction joint planes and between 200 and 500 mm thick unless otherwise permitted or directed by the Head of works. The layers shall be placed such that no feather edges are formed and before the preceding layer has taken its initial set. In order to comply with this requirement, a layer may be started before completion of the preceding layer.

Fresh concrete shall not be placed against concrete that has been in position for more than 30 minutes, unless a construction joint is formed.

In bridge decks of substantial thickness, care shall be taken to avoid layering of the concrete, and each panel or bay shall be placed to the full depth in one pass before proceeding to the next panel or bay.

All of the concrete in a single bay or pour shall be placed as a continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely filled with compacted concrete with no segregation or honeycombing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items that protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has
partially hardened during transit shall be used in the Works.

Concrete shall not be placed during rain, which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In drying weather, covers shall be provided for all fresh concrete surfaces that are not being worked on. Water shall not be added to concrete for any reason.

20.9.5 Placing under water

Placing under water shall be allowed only in exceptional circumstances where it is unfeasible to dewater the location before the concrete is placed, and only if approved in the Environmental Management Plan. The pH of the water shall be monitored. No concrete shall be placed in running water.

When it is necessary to place concrete under water the Owner or Owner’s Authorised Agent shall submit to the Head of works his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies with a trapdoor or sliding plug fitted at the discharging end.

When concreting by tremie, the pipe shall be kept continuously full with concrete to a level above the water and shall have the discharge end kept well below the surface of the concrete, in order to prevent air and water from entering the tremie. Should this seal be broken, or the level of the concrete is allowed to fall sufficiently for water to enter the pipe, the tremie shall be lifted, plugged and re-filled before concreting is recommenced. Special care shall be taken to control the rate of descent so as to avoid segregation.

Distribution of concrete by lateral movement of the tremie will not be permitted.

During and after concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

The concrete mix to be placed under water shall be specially designed and approved for this purpose, to ensure good flowability, plasticity and cohesion. Increased sand and cement content over those of normal mixes will usually be required.

20.9.6 Interruptions to placing

If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Owner or Owner’s Authorised Agent shall complete the compaction of the placed concrete and immediately take the necessary action to form a construction joint in accordance with this Code, Equipment and materials to comply with this requirement shall be readily available at all times during concrete placing.

Before concreting is resumed after such an interruption the Owner or Owner’s Authorised Agent shall cut out and remove all damaged, contaminated or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing within 30 minutes of the stoppage and the Head of works consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the surface of the existing concrete so as to avoid any cold joints.

20.9.7 Dimensions of pours

Unless otherwise approved by the Head of works, pours shall not be more than 2.0 m high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the circumstances described in this Code.

The Owner or Owner’s Authorised Agent shall plan the dimensions and sequence of pours in such a way that cracking of the concrete does not take place due to thermal or shrinkage stresses.
20.10 COMPACTION OF CONCRETE

The concrete shall be fully compacted throughout the full volumetric extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement, tendons, ducts and other embedded items, without displacing them. Particular care shall be taken at arrises and other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

In bridge decks with void formers, adequate means to prevent flotation shall be employed, and care shall be taken to ensure adequate compaction of the concrete placed beneath the void formers.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Head of works agrees to another method.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, stand-by vibrators shall be available for instant use at each location where concrete is being placed.

Where the concrete contains aggregate with a nominal size of 63 mm or more, vibrators with a diameter of 100 mm or more shall be used.

Vibration shall be applied by experienced workmen, and over-vibration resulting in segregation, surface water and leakage, shall be avoided.

Vibration shall be continued at each point until the concrete ceases to contract, a thin layer of mortar has appeared on the surface and air bubbles have ceased to appear. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

Vibration shall not be applied by shaking the reinforcement nor shall vibrators be allowed to touch reinforcement or other embedded items. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing, which shall not exceed the distance from the vibrator over which vibration is visibly effective.

Special attention shall be given in prestressing anchor zones, behind anchor plates and in places where a high concentration of reinforcing steel or cables occurs.

20.11 CURING AND PROTECTION OF CONCRETE

20.11.1 General

During the first stage of hardening, concrete shall be protected from loss of moisture and from the development of temperature differentials within the concrete, which may be sufficient to cause cracking. Curing shall be continued for at least 7 days for concrete made with CEM I cement and for at least 10 days for concrete made with CEM II and CEM III cement, or until the concrete is covered by later construction, whichever is the shorter period.

The curing process shall commence as soon as the concrete has hardened sufficiently to resist damage from the process. In the case of large areas or continuous pours, the curing process shall commence on the completed clauses before completion of the remaining pour.

Details of the Owner or Owner’s Authorised Agent’s proposals for curing concrete shall be submitted to the Head of works for approval before the placing of concrete commences.

In addition, the Owner or Owner’s Authorised Agent shall, where feasible, provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

20.11.2 Loss of moisture

Protection against loss of moisture shall be achieved by one or more of the following methods:

(i) Retaining formwork in place for the full curing period.
(ii) Closely covering exposed concrete surfaces with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300 mm.
(iii) Covering with sand or with mats made from a moisture retaining material, and keeping the covering constantly wet.

(iv) Keeping the exposed surfaces continuously wet by means of a water spray, only where other methods are not possible. Alternate wetting and drying, and cold water on warm concrete surfaces shall be avoided. This method shall not be used in the case of thick concrete clauses or in other situations where there is a risk of a high temperature differential between the concrete surface and its core.

Water used for curing shall comply with Subclause (d).

(v) If use of the foregoing methods is inappropriate, surfaces that will not have further concrete bonded to them and which are not to receive an application of a finish may be cured by the application of a curing compound having an efficiency index of at least 90%. Curing compounds shall contain a fugitive dye to enable the extent of the spread to be seen easily.

Curing compound used on surfaces exposed to sunlight shall contain sufficient finely divided flake aluminium in suspension to produce a complete coverage of the surface with a metallic finish when applied at the rate recommended by the manufacturer.

Curing compounds shall become stable and impervious to the evaporation of water from the concrete surface within 60 minutes of application. The material shall not react chemically with the concrete and shall not crack, peel or disintegrate within three weeks after application.

20.11.3 Limitation of temperature differentials

The Owner or Owner’s Authorised Agent shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances including the following:

(i) limiting concrete temperatures at placing as set out in Subclause;
(ii) use of low heat cement, subject to the approval of the Head of works;
(iii) insulation of exposed concrete surfaces by insulating blankets. Such blankets shall have an insulation value at least equivalent to 50 mm of dry mineral wool;
(iv) leaving formwork in place during the curing period. Steel forms shall be suitably insulated on their external surfaces;
(v) preventing rapid dissipation of heat from surfaces by shielding from wind;
(vi) avoiding the use of water sprays when such use would cause rapid cooling of the surface.

20.12 PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.

Concrete placed in the Works shall not be subject to any loading until it has attained at least its nominal strength as defined in this Code.

No load shall be applied to any part of the structure until the specified curing period has expired, after which applied loading shall be allowed only when approved by the Head of works. The Head of works’s decision will be based on the type of load to be applied, the age of the structure, the magnitude of stress induced and the propping of the structure.

If the Owner or Owner’s Authorised Agent desires to impose loads on newly-placed concrete, he shall make at least three test cubes and cure them in the same conditions as the concrete they represent. These cubes shall be tested singly at suitable intervals in order to estimate the time at which the required strength is reached.
No structure shall be opened to traffic until the test samples made from the concrete in all parts of the structure have attained the specified minimum 28-day compressive strength.

20.13 CONCRETING IN HOT WEATHER

During hot weather the Owner or Owner’s Authorised Agent shall take all measures necessary to ensure that the temperature of concrete at the time of placing does not exceed 30°C and that the risk of moisture loss from the concrete during transporting and placing is minimised.

Such measures include but are not necessarily limited to the following:-

(i) Shielding aggregate stockpiles from direct sunshine.
(ii) Use of a mist water spray on aggregates to promote cooling down by evaporation.
(iii) Sun shields on mixing plants and transporting equipment.
(iv) Cooling the mixing water. If ice is used for this purpose it should preferably be in flake form. Lump ice shall not be allowed to enter the tank supplying the mixer drum.
(v) Covering skips closely with polythene sheet so that the latter is in contact with the concrete.

Areas in which concrete is to be placed shall be shielded from direct sunshine and hard rock or concrete surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete in any part of an area has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

In the event that conditions become such that even with the use of such precautions, the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

20.14 FINISHES ON UNFORMED SURFACES

Horizontal or nearly horizontal surfaces, which are not cast against formwork shall be finished to the class shown on the Drawings and defined hereunder.

20.14.1 UF 1 finish

All surfaces on which no higher class of finish is called for on the Drawings or instructed by the Head of works shall be given a UF 1 finish.

The concrete shall be levelled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

20.14.2 UF 2 finish

This is a floated finish surface where a steel trowelled surface is not required.

The surface shall first be treated as a Class UF 1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficient only to produce a uniform surface free from screed marks.

20.14.3 UF 3 finish

This is a steel trowelled surface for use where weather resistance or appearance is important, or where the surface will be subjected to a high velocity water flow.

The surface shall be floated as for a UF 2 Finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

Where dimensional tolerances are given on the Drawings or in the Special Specification they shall take precedence over those given in Table 20.6.

Table 20.6 - Surface Tolerances
20.15 MORTAR
This clause covers mortar for use ahead of concrete placing in construction joints, for filling small cavities in damaged concrete surfaces, and for any other uses as indicated on the Drawings or instructed by the Head of works, which are not covered elsewhere in the Specification.

Mortar shall be composed of Portland cement and fine aggregate complying with Subclause 0 (b) and (c) respectively. The mix proportions shall be as stated on the Drawings or elsewhere in the Specification or if not stated shall be one part of cement to two parts of fine aggregate by mass.

Small quantities of mortar may be hand mixed but for amounts over 0.5 m³ a mechanical mixer shall be used

The water content of the mortar shall be as low as possible consistent with the use for which it is required but in any case the water/cement ratio shall not be more than 0.5.

Mortar that is specified as 'dry pack' shall be mixed with sufficient water for the mix to become cohesive but not plastic when squeezed in the hand. Dry pack mortar shall be rammed into the cavity it is required to fill, using a hand rammer with sufficient force to ensure full compaction.

20.16 CONCRETE FOR SECONDARY PURPOSES

(a) Non-structural concrete shall be used only for non-structural purposes where shown on the Drawings.

Non-structural concrete shall be weigh batched or volume batched in accordance with the prescribed nominal concrete mixes indicated in Clause 0, and mixed by machine or by hand to a uniform colour and consistency before placing.

Non-structural concrete shall be classified with the prefix NS and the nominal cube crushing strength. Class NS 15 concrete shall mean non-structural concrete with a nominal cube strength of 15 MPa or mixed in a volume ratio of one part cement: three parts sand: six parts stone (Table 20.4). The nominal stone size shall be appropriate to the use for which the non-structural concrete will be employed, and shall be subject to the approval of the Head of works.

Concrete shall be compacted by hand or by mechanical vibration.

Where non-structural concrete is required, but no class is specified, Class NS 15 shall be used.

(b) No Fines concrete (NF concrete) is intended for use where a porous concrete is required and shall only be used where shown on the Drawings or instructed by the Head of works.

The mix shall consist of Portland cement complying with GS 22 or BS EN 197 and aggregate complying with BS EN 12620. The aggregate size shall be 40 mm to 10 mm only. The mass of cement mixed with 0.3 m³ of aggregate shall not be less than 50 kg. The quantity of water shall
not exceed that required to produce a smooth cement paste that will evenly coat the whole of the aggregate.

20.17 RECORDS OF CONCRETE PLACING

Records, in a form approved by the Head of works, shall be kept by the Owner or Owner’s Authorised Agent of the details of every pour of concrete placed. These records shall include class of concrete, location of pour, date of pour, ambient temperature and concrete temperature at time of placing, moisture contents of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cube sample points and details of any cores taken and any spillages in water courses.

The Owner or Owner’s Authorised Agent shall supply to the Head of works two copies of these records each week covering work carried out the preceding week. In addition he shall supply to the Head of works monthly histograms of all 28 day cube strengths together with accumulative and monthly standard deviations and any other information that the Head of works may require concerning the concrete placed in the Works.

20.18 CONSTRUCTION JOINTS

20.18.1 General

Where a concrete element has to be constructed in more than one concreting operation, the surface of contact between the clauses shall be deemed a construction joint.

Construction joints shall be formed at the positions shown on the Drawings, or, approved by the Head of works. Where, in an emergency (such as a breakdown in the mixing or placing plant, or the occurrence of unsuitable weather), concreting has to be interrupted, a construction joint shall be formed at the place of stoppage, in a manner that will least impair the appearance, durability, and proper functioning of the concrete.

Unless otherwise indicated, construction joints shall be in horizontal or vertical planes, except in inclined members, where they shall be perpendicular to the line or plane of the member.

Where additional joints are required by the Owner or Owner’s Authorised Agent to suit his method of construction, they shall be so arranged as to reduce to a minimum the effects of shrinkage in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints. All joints additional to those shown on the Drawings, shall be subject to the Head of works’s approval.

Feather edges of concrete at joints shall be avoided and any feather edges that may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The interclauses of horizontal or near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the formwork at the top of the concrete lift, or by other means acceptable to the Head of works.

Construction joints formed as free surfaces shall not exceed a slope of 20% from the horizontal.

20.18.2 Preparation of surfaces

In horizontal joints, when the concrete has set but not yet hardened, the joint surface shall be thoroughly cleaned and roughened by means of a water jet, assisted by light brushing, to expose the aggregate without disturbing it, and to leave a sound irregular surface. Vertical or near vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time.

Where concrete has become too hard for the above treatment to be successful, the joint surface, whether formed or free, shall be roughened by sand blasting, or by applying a scaling hammer or other mechanical means...
appropriate to the degree of hardness of the concrete, so as to expose the aggregate and leave a sound irregular surface. The roughened surface shall be thoroughly washed with clean water to remove all dirt and loose particles. The indentations produced by roughening shall not be less than 10 mm deep and shall not extend closer than 40 mm to a finished face.

Surface retarding agents shall not be used at construction joints without the Head of works’s approval.

20.18.3 Placing of fresh concrete
Where fresh concrete is placed on the same day as the formation of the construction joint, the fresh concrete shall be cast directly against the prepared face of the construction joint.

Where fresh concrete is placed a day or more after formation of the construction joint, the joint surface shall be kept continuously wet for at least six hours before concreting commences. The surface shall be in a saturated, surface-dry condition when the concrete is placed.

If instructed by the Head of works, the surface of the concrete shall be thoroughly brushed with a thin layer of mortar composed of one part of cement to two parts of sand by mass and complying with this code immediately prior to the deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

No mortar or concrete may be placed in position on or against a construction joint until the joint has been inspected and passed by the Head of works.

Where specified, bonding agents, designed for joining new concrete to old, shall be used in construction joints. The type and proprietary brand of bonding agent used shall be subject to the Head of works’s approval. The preparation of the concrete surface and the application of the bonding agent shall be strictly in accordance with the manufacturer’s recommendations.

20.19 EXPANSION AND CONTRACTION JOINTS

Expansion and contraction joints are discontinuities in concrete designed to allow for thermal or other movements in the concrete.

Expansion joints are formed with a gap between the concrete faces to permit subsequent expansion of the concrete. Contraction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling.

Expansion and contraction joints shall be formed in the positions and in accordance with the details shown on the Drawings or elsewhere in the Specifications.

20.20 PRECAST CONCRETE

20.20.1 General

This clause covers all precast reinforced and prestressed concrete units, whether detailed in the original design, or proposed by the Owner or Owner’s Authorised Agent, but excludes precast concrete piles, pipes and culverts, in so far as they are covered separately elsewhere in the Specification.

20.20.2 Casting of Units

Precast units shall be manufactured in accordance with all relevant requirements specified for cast in-situ members, except as specified differently hereunder.

All units shall be permanently marked with the reference number, location, orientation and date of casting. These markings shall be positioned such that they will not be visible in the completed structure.

The area in which units are cast shall be adequately protected from the weather so that the process is not affected by rain, sun or drying winds.
20.20.3 Curing of Precast Units

If curing of precast units at elevated temperatures is proposed, the method shall be subject to the Head of works’s approval, and shall include means whereby units are heated and subsequently cooled evenly, without sudden changes of temperature. It shall furthermore, not cause staining, contamination or marring of the concrete surface.

20.20.4 Surface Finish of Unformed Surfaces of Precast Units

Unformed surfaces shall be finished to Class UF2 unless another class of finish is specified on the Drawings.

Those parts of the unit that are to be joined to other units or to in situ concrete shall be brushed with a stiff brush before the concrete has fully hardened. Alternatively, if the concrete has been allowed to harden, the surfaces shall be roughened by sand blasting or by the use of a needle gun.

20.20.5 Handling and Storage of Precast Units

Precast units shall be handled in a manner that will not cause damage of any kind and shall be stored on a hard impermeable base.

Prestressed units and large precast normally reinforced units shall be handled and stored so that no stresses will be induced in excess of those which they will incur in their final positions in the Works unless they have been designed to resist such stresses.

Units shall be marked indelibly with the reference number and date of casting and shall be stacked on suitable supports, which will not damage the concrete or stain the surfaces. Not more than two supports shall be placed under each unit and these shall be located either at the positions of the permanent support points or in positions such that the induced stresses in the unit will be a minimum.

20.21 Testing Precast Units

Precast units shall be capable of safely sustaining the loads that they have been designed to carry. The Owner or Owner’s Authorised Agent shall subject units selected by the Head of works to load tests simulating the working conditions. Details of such tests shall be agreed between the Head of works and the Owner or Owner’s Authorised Agent.

In the case of units subject to bending loads the test piece shall be supported at full span and a loading equivalent to 1.25 times the sum of the live and dead loads, which were assumed in the design shall be maintained for one hour without the appearance of any signs of distress. The recovery one hour after the removal of load shall be not less than 75% of the full load deflection.

If the unit fails to meet the above requirements, further tests shall be carried out on two more units. If either of these fails, the whole batch of units will be rejected.

If the Head of works so requires, a test to destruction shall also be carried out, which on units subject to bending shall also be carried out, which on units subject to bending shall be as follows:

The units shall be supported at full span and a load applied in increments instructed by the Head of works up to 95% of the designed ultimate load. This load shall be held for 15 minutes without failure of the unit. The deflection at the end of this period shall not be more than l/40th of the span. The load shall then be further increased until failure occurs.

If the unit fails to sustain the required load for the prescribed period or if the deflection exceeds the specified amount, the Head of works may order two further tests, and if either of these fails, the batch of units which they represent may be rejected.

PART 21: ALUMINIUM

User notes:

About this part: Part 21 contains standards for the use of aluminium in building construction. Both structural and nonstructural applications of aluminium are addressed. It also applies to the use of aluminium in specialty products such as storefront or window framing or architectural hardware.
21.1 GENERAL

21.1 Scope.

This part covers the quality, design, fabrication and use of aluminium.

1. Aluminium and other light metals and their Alloys

   IS: 733 Specification for wrought aluminium and aluminium alloys, bars, rods and clauses for general engineering purposes.

   IS: 737 Specification for wrought aluminium and aluminium alloys, sheet rods and strip for general engineering purposes.

   GS IS: 738 Specification for wrought aluminium and aluminium alloy drawn tube for general engineering purposes.

   GS IS: 740 Specification for wrought aluminium alloy rivet stock for general engineering purposes.

   GS IS: 1254 Specification for corrugated aluminium sheet.

   GS IS: 1284 Wrought aluminium alloy bolt and screw stock for general engineering purposes.

   GS IS: 1285 Specification for wrought aluminium and aluminium alloys, extruded round tube and hollow clauses for general engineering purposes.

   GS IS: 2479 Colour Code for the identification of aluminium and aluminium alloys for general engineering purposes.

   GS IS: 2676 Dimensions for wrought aluminium and aluminium alloy sheet and strip.

   GS IS: 2677 Dimensions for wrought aluminium and aluminium alloys, plates and hot rolled sheets.


   GS BS 5286: Specification for aluminium framed sliding doors.

   GS BS 1161: Specification for aluminium alloy clauses for structural purposes.

   GS BS 4868: Profiled aluminium sheet for building.

   GS BS 4300: Specification for wrought aluminium and aluminium alloys for general engineering purposes.

   GS BS EN 485: Aluminium and aluminium alloys – Sheet, strip and plate.

   GS BS EN 573: Aluminium and aluminium alloys – Chemical composition and form of wrought products.

21.2 MATERIALS

21.2.1 General.

Aluminium used for structural purposes in buildings and structures shall comply with this Code. The nominal loads shall be the minimum design loads required by Part 17.
PART 22: MASONRY

User notes:

About this part: part 22 establishes minimum requirements for masonry construction. The provisions address: material specifications and test methods; types of wall construction; criteria for engineered and empirical designs; and required details of construction, including the execution of construction. The provisions provide a framework for applying applicable standards to the design and construction of masonry structures. Masonry design methodologies including allowable stress design, strength design and empirical design are covered by the provisions of this part. Also addressed are masonry fireplaces and chimneys, masonry heaters and glass unit masonry.

22.1 GENERAL

22.1.1 Scope.

This part shall govern the materials, design, construction and quality of masonry.

22.1.2 Design methods.

Masonry shall comply with the provisions of TMS 402, TMS 403 or TMS 404 as well as applicable requirements of this part.

22.1.2.1 Masonry veneer.

Masonry veneer shall comply with the provisions of Part 15.

22.1.3 Special inspection.

The special inspection of masonry shall be as defined in Part 19 or an itemized testing and inspection program shall be provided that meets or exceeds the requirements of Part 19.

22.2 NOTATIONS

22.2.1 General.

The following notations are used in the part:

NOTATIONS.

\[ d_b = \text{Diameter of reinforcement, inches (mm).} \]
\[ F_s = \text{Allowable tensile or compressive stress in reinforcement, psi (MPa).} \]
\[ f_r = \text{Modulus of rupture, psi (MPa).} \]
\[ f_{\text{AAC}} = \text{Specified compressive strength of AAC masonry, the minimum} \]
\[ f'_m = \text{Specified compressive strength of masonry at age of 28 days, psi (MPa).} \]
\[ f'_{\text{mi}} = \text{Specified compressive strength of masonry at the time of prestress transfer, psi (MPa).} \]
\[ K = \text{The lesser of the masonry cover, clear spacing between adjacent reinforcement, or five times } d_b \text{ inches (mm).} \]
\[ L_s = \text{Distance between supports, inches (mm).} \]
\[ L_d = \text{Required development length or lap length of reinforcement, inches (mm).} \]
\[ P = \text{The applied load at failure, pounds (N).} \]
\[ S_t = \text{Thickness of the test specimen measured parallel to the direction of load, inches (mm).} \]
\[ S_w = \text{Width of the test specimen measured parallel to the loading cylinder, inches (mm).} \]

22.3 MASONRY CONSTRUCTION MATERIALS

22.3.1 Masonry units.

Concrete masonry units, clay or shale masonry units, stone masonry units, glass unit masonry and AAC masonry units shall comply with Article 2.3 of TMS 602. Architectural cast stone shall conform to ASTM C1364 and TMS 504. Adhered manufactured stone masonry veneer units shall conform to ASTM C1670.

Exception: Structural clay tile for nonstructural use in fireproofing of structural members and in wall furring shall not be required to meet the compressive strength specifications. The fire-resistance rating shall be determined in accordance with ASTM E119 and shall comply with the requirements of Table 602.

22.3.1.1 Second-hand units.

Second-hand masonry units shall not be reused unless they conform to the requirements of new
units. The units shall be of whole, sound materials and free from cracks and other defects that will interfere with proper laying or use. Old mortar shall be cleaned from the unit before reuse.

22.3.2 Mortar.
Mortar for masonry construction shall comply with Clause 22.3.2.1, 22.3.2.2, 22.3.2.3 or 22.3.2.4.

22.3.2.1 Masonry mortar.
Mortar for use in masonry construction shall conform to this Code.

22.3.2.2 Surface-bonding mortar.
Surface-bonding mortar shall comply with ASTM C887. Surface bonding of concrete masonry units shall comply with ASTM C946.

22.3.2.3 Mortars for ceramic wall and floor tile.
Portland cement mortars for installing ceramic wall and floor tile shall comply with BS EN 12004.

22.3.2.3.1 Dry-set Portland cement mortars.
Premixed prepared Portland cement mortars, which require only the addition of water and are used in the installation of ceramic tile, shall comply with this Code. The shear bond strength for tile set in such mortar shall be as required in accordance with this Code. Tile set in dry-set Portland cement mortar shall be installed in accordance with this Code.

22.3.2.3.2 Latex-modified Portland cement mortar.
Latex-modified Portland cement thin-set mortars in which latex is added to dry-set mortar as a replacement for all or part of the gauging water that are used for the installation of ceramic tile shall comply with this Code. Tile set in latex-modified Portland cement shall be installed in accordance with this Code.

22.3.2.3.3 Epoxy mortar.
Ceramic tile set and grouted with chemical-resistant epoxy shall comply with this Code. Tile set and grouted with epoxy shall be installed in accordance with this Code.

22.3.2.3.4 Furan mortar and grout.
Chemical-resistant furan mortar and grout that are used to install ceramic tile shall comply with this Code. Tile set and grouted with furan shall be installed in accordance with this Code.

22.3.2.3.5 Modified epoxy-emulsion mortar and grout.
Modified epoxy-emulsion mortar and grout that are used to install ceramic tile shall comply with this Code. Tile set and grouted with modified epoxy-emulsion mortar and grout shall be installed in accordance with this Code.

22.3.2.3.6 Organic adhesives.
Water-resistant organic adhesives used for the installation of ceramic tile shall comply with this Code. The shear bond strength after water immersion shall be not less than 275 kPa (40 psi) for Type I adhesive and not less than 138 kPa (20 psi) for Type II adhesive when tested in accordance with this Code. Tile set in organic adhesives shall be installed in accordance with this Code.

22.3.2.3.7 Portland cement grouts.
Portland cement grouts used for the installation of ceramic tile shall comply with this Code. Portland cement grouts for tile work shall be installed in accordance with this Code.

22.3.2.4 Mortar for adhered masonry veneer.
Mortar for use with adhered masonry veneer shall conform to ASTM C270 for Type N or S, or shall comply with this Code for latex-modified Portland cement mortar.
22.3.3 Grout.
Grout shall comply with this Code.

22.3.4 Metal reinforcement and accessories.
Metal reinforcement and accessories shall conform to Article 2.4 of TMS 602. Where unidentified reinforcement is approved for use, not less than three tension and three bending tests shall be made on representative specimens of the reinforcement from each shipment and grade of reinforcing steel proposed for use in the work.

22.4 CONSTRUCTION

22.4.1 Masonry construction.
Masonry construction shall comply with the requirements of Clauses 22.4.1.1 through 22.4.1.3 and with the requirements of either TMS 602 or TMS 604.

22.4.1.1 Support on wood.
Masonry shall not be supported on wood girders or other forms of wood construction except as permitted in Clause 22.4.12.

22.4.1.2 Molded cornices.
Unless structural support and anchorage are provided to resist the overturning moment, the center of gravity of projecting masonry or molded cornices shall lie within the middle one-third of the supporting wall. Terra cotta and metal cornices shall be provided with a structural frame of approved noncombustible material anchored in an approved manner.

22.5 QUALITY ASSURANCE

22.5.1 General.
A quality assurance program shall be used to ensure that the constructed masonry is in compliance with the approved construction documents.

The quality assurance shall comply with the inspection and testing requirements of Part 19 of this Code.

22.6 SEISMIC DESIGN

22.6.1 Seismic design requirements for masonry.
Masonry structures and components shall comply with the requirements in Part 19 of this Code depending on the structure’s seismic design zones.

22.7 ALLOWABLE STRESS DESIGN

22.7.1 General.
The design of masonry structures using allowable stress design shall comply with Clause 22.6 and the requirements of Parts 1 through 8 of TMS 402 except as modified by Clauses 22.7.2 through 22.7.3.

22.7.2 TMS 402, Clause 6.1.6.1.1, lap splices.
As an alternative to Clause 6.1.6.1.1, it shall be permitted to design lap splices in accordance with Clause 22.7.2.1.

22.7.2.1 Lap splices.
The minimum length of lap splices for reinforcing bars in tension or compression, \( l_d \), shall be:

\[
\frac{l_d}{d} = 0.002d \left( \frac{f}{b s} \right) \quad \text{(Equation 21-1)}
\]

For SI:

\[
\frac{l_d}{d} = 0.29d \left( \frac{f}{b s} \right)
\]

But not less than 12 inches (305 mm). The length of the lapped splice shall be not less than 40 bar diameters.

Where:

\[
\begin{align*}
\frac{d}{b} & = \text{Diameter of reinforcement, inches (mm).} \\
\frac{f}{s} & = \text{Computed stress in reinforcement due to design loads, psi (MPa).}
\end{align*}
\]

In regions of moment where the design tensile stresses in the reinforcement are greater than...
80 percent of the allowable steel tension stress, $F_s$, the lap length of splices shall be increased not less than 50 percent of the minimum required length, but need not be greater than 72 db. Other equivalent means of stress transfer to accomplish the same 50 percent increase shall be permitted. Where epoxy coated bars are used, lap length shall be increased by 50 percent.

22.7.3 TMS 402, Clause 6.1.6.1, splices of reinforcement.
Modify Clause 6.1.6.1 as follows:

6.1.6.1 – Splices of reinforcement. Lap splices, welded splices or mechanical splices are permitted in accordance with the provisions of this clause. Welding shall conform to EN 310 D1.4. Welded splices shall be of ASTM A706 steel reinforcement. Reinforcement larger than No. 9 (M #29) shall be spliced using mechanical connections in accordance with Clause 6.1.6.1.3.

22.8 STRENGTH DESIGN OF MASONRY

22.8.1 General.
The design of masonry structures using strength design shall comply with Clause 2106 and the requirements of Parts 1 through 7 and Part 9 of TMS 402, except as modified by Clauses 22.8.2 through 22.8.3.

Exception: AAC masonry shall comply with the requirements of Parts 1 through 7 and Part 11 of TMS 402.

22.8.2 TMS 402, Clause 6.1.5.1.1, development.
Modify the second paragraph of Clause 6.1.5.1.1 as follows:

The required development length of reinforcement shall be determined by Equation (6-1), but shall be not less than 305 mm (12 inches) and need not be greater than 72 dB.

22.8.3 TMS 402, Clause 6.1.6.1.1, splices.
Modify Clauses 6.1.6.1.2 and 6.1.6.1.3 as follows:

6.1.6.1.2 – A welded splice shall have the bars butted and welded to develop not less than 125 percent of the yield strength, $f_y$, of the bar in tension or compression, as required. Welded splices shall be of ASTM A706 steel reinforcement. Welded splices shall not be permitted in plastic hinge zones of intermediate or special reinforced walls.

6.1.6.1.3 – Mechanical splices shall be classified as Type 1 or 2 in accordance with Clause 18.2.7.1 of Ghana Construction Standard Part 2. Type 1 mechanical splices shall not be used within a plastic hinge zone or within a beam-column joint of intermediate or special reinforced masonry shear walls. Type 2 mechanical splices are permitted in any location within a member.

22.9 EMPIRICAL DESIGN OF ADOBE MASONRY

22.9.1 General.
Empirically designed adobe masonry shall conform to the requirements of Appendix A of TMS 402, except where otherwise noted in this clause.

22.9.1.1 Limitations.
The use of empirical design of adobe masonry shall be limited as noted in Clause A.1.2 of TMS 402. In buildings that exceed one or more of the limitations of Clause A.1.2 of TMS 402, masonry shall be designed in accordance with the engineered design provisions of Clause 22.1.2 or the foundation wall provisions of Clause 18.7.1.5. Clause A.1.2.2 of TMS 402 shall be modified as follows:

A.1.2.2 – Wind. Empirical requirements shall not apply to the design or construction of masonry for buildings, parts of buildings, or other structures to be located in areas where $V_{asd}$ determined in accordance with part 17 of the In this Code exceeds 110 mph.

22.9.2 Adobe construction.
Adobe construction shall comply with this clause and shall be subject to the requirements of this Code for Type V construction, Appendix A of TMS 402, and this clause.
22.9.2.1 Unstabilized adobe.

Unstabilized adobe shall comply with Clauses 22.9.2.1.1 through 22.9.2.1.4.

22.9.2.1.1 Compressive strength.

Adobe units shall have an average compressive strength of 2068 kPa (300 psi) when tested in accordance with ASTM C67. Five samples shall be tested and individual units are not permitted to have a compressive strength of less than 1724 kPa (250 psi).

22.9.2.1.2 Modulus of rupture.

Adobe units shall have an average modulus of rupture of 345 kPa (50 psi) when tested in accordance with the following procedure. Five samples shall be tested and individual units shall not have a modulus of rupture of less than 241 kPa (35 psi).

22.9.2.1.2.1 Support conditions.

A cured unit shall be simply supported by 51 mm (2-inch-diameter) cylindrical supports located 51 mm (2 inches) in from each end and extending the full width of the unit.

22.9.2.1.2.2 Loading conditions.

A 2-inch-diameter (51 mm) cylinder shall be placed at midspan parallel to the supports.

22.9.2.1.2.3 Testing procedure.

A vertical load shall be applied to the cylinder at the rate of 37 N/s (500 pounds per minute) until failure occurs.

22.9.2.1.2.4 Modulus of rupture determination.

The modulus of rupture shall be determined by the equation:

\[ f_r = \frac{3PL}{2S_w S_t^2} \]

Where, for the purposes of this clause only:

- \( S_w \) = Width of the test specimen measured parallel to the loading cylinder, inches (mm).
- \( f_r \) = Modulus of rupture, psi (MPa).
- \( L_s \) = Distance between supports, inches (mm).
- \( S_t \) = Thickness of the test specimen measured parallel to the direction of load, inches (mm).
- \( P \) = The applied load at failure, pounds (N).

22.9.2.1.3 Moisture content requirements.

Adobe units shall have a moisture content not exceeding 4 percent by weight.

22.9.2.1.4 Shrinkage cracks.

Adobe units shall not contain more than three shrinkage cracks and any single shrinkage crack shall not exceed 76 mm (3 inches) in length or 3.2 mm (\( \frac{1}{8} \) inch) in width.

22.9.2.2 Stabilized adobe.

Stabilized adobe shall comply with Clause 22.9.2.1 for unstabilized adobe in addition to Clauses 22.9.2.2.1 and 22.9.2.2.2.

22.9.2.2.1 Soil requirements.

Soil used for stabilized adobe units shall be chemically compatible with the stabilizing material.

22.9.2.2.2 Absorption requirements.

A 102 mm (4-inch) cube, cut from a stabilized adobe unit dried to a constant weight in a ventilated oven at 212°F to 239°F (100°C to 115°C), shall not absorb more than \( \frac{1}{2} \) percent moisture by weight when placed on a constantly water-saturated, porous surface for seven days.

Not fewer than five specimens shall be tested.
and each specimen shall be cut from a separate unit.

**22.9.2.3 Allowable stress.**
The allowable compressive stress based on gross cross-clauseal area of adobe shall not exceed 207 kPa (30 psi).

**22.9.2.3.1 Bolts.**
Bolt values shall not exceed those set forth in Table 22.9.2.3.1.

<table>
<thead>
<tr>
<th>DIAMETER OF BOLTS (inches)</th>
<th>MINIMUM EMBEDMENT (inches)</th>
<th>SHEAR (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 / 2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5 / 8</td>
<td>12</td>
<td>200</td>
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<tr>
<td>3 / 4</td>
<td>15</td>
<td>300</td>
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<tr>
<td>1 / 8</td>
<td>21</td>
<td>500</td>
</tr>
<tr>
<td>1 / 2</td>
<td>24</td>
<td>600</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound = 4.448 N.

**22.9.2.4 Detailed requirements.**
Adobe construction shall comply with Clauses 22.9.2.4.1 through 22.9.2.4.9.

**22.9.2.4.1 Number of stories.**
Adobe construction shall be limited to buildings not exceeding one storey, except that two-storey construction is allowed where designed by a registered design professional.

**22.9.2.4.2 Mortar.**
Mortar for adobe construction shall comply with Clauses 22.9.2.4.2.1 and 22.9.2.4.2.2.

**22.9.2.4.2.1 General.**
Mortar for adobe units shall be in accordance with Clause 22.3.2.1, or be composed of adobe soil of the same composition and stabilization as the adobe brick units. Unstabilized adobe soil mortar is permitted in conjunction with unstabilized adobe brick units.

**22.9.2.4.2.2 Mortar joints.**
Adobe units shall be laid with full head and bed joints and in full running bond.

**22.9.2.4.3 Parapet walls.**
Parapet walls constructed of adobe units shall be waterproofed.

**22.9.2.4.4 Wall thickness.**
The minimum thickness of exterior walls in one-storey buildings shall be 254 mm (10 inches). The walls shall be laterally supported at intervals not exceeding 7315 mm (24 feet). The minimum thickness of interior load-bearing walls shall be 203 mm (8 inches). The unsupported height of any wall constructed of adobe units shall not exceed 10 times the thickness of such wall.

**22.9.2.4.5 Foundations.**
Foundations for adobe construction shall be in accordance with Clauses 22.9.2.4.5.1 and 22.9.2.4.5.2.

**22.9.2.4.5.1 Foundation support.**
Walls and partitions constructed of adobe units shall be supported by foundations or footings that extend not less than 152 mm (6 inches) above adjacent ground surfaces and are constructed of solid masonry (excluding adobe) or concrete. Footings and foundations shall comply with Part 18.

**22.9.2.4.5.2 Lower course requirements.**
Stabilized adobe units shall be used in adobe walls for the first 102 mm (4 inches) above the finished first-floor elevation.

**22.9.2.4.6 Isolated piers or columns.**
Adobe units shall not be used for isolated piers or columns in a load-bearing capacity. Walls
less than 24 inches (610 mm) in length shall be considered to be isolated piers or columns.

22.9.2.4.7 Tie beams.

Exterior walls and interior load-bearing walls constructed of adobe units shall have a continuous tie beam at the level of the floor or roof bearing and meeting the following requirements.

22.9.2.4.7.1 Concrete tie beams.

Concrete tie beams shall be 152 mm (6 inches) or more in depth and 254 mm (10 inches) or more in width. Concrete tie beams shall be continuously reinforced with not fewer than two No. 4 reinforcing bars. The specified compressive strength of concrete shall be not less than 17.2 MPa (2,500 psi).

22.9.2.4.7.2 Wood tie beams.

Wood tie beams shall be solid or built up of timber having a nominal thickness of not less than 25 mm (1 inch), and shall have a depth of not less than 152 mm (6 inches) and a width of not less than 254 mm (10 inches). Joints in wood tie beams shall be spliced not less than 152 mm (6 inches). Splices shall not be allowed within 305 mm (12 inches) of an opening. Wood used in tie beams shall be approved naturally decay-resistant or preservative-treated wood.

22.9.2.4.8 Exterior finish.

Exterior walls constructed of unstabilized adobe units shall have their exterior surface covered with not fewer than two coats of Portland cement plaster having a minimum thickness of 19.1 mm (3/4 inch) and conforming to ASTM C926. Lathing shall comply with ASTM C1063. Fasteners shall be spaced at 406 mm (16 inches) on center maximum. Exposed wood surfaces shall be treated with an approved wood preservative or other protective coating prior to lath application.

22.9.2.4.9 Lintels.

Lintels shall be considered to be structural members and shall be designed in accordance with the applicable provisions of Part 17.

22.10 GLASS UNIT MASONRY

22.10.1 General.

Glass unit masonry construction shall comply with Part 13 of TMS 402 and this clause.

22.10.1.1 Limitations.

Solid or hollow approved glass block shall not be used in fire walls, party walls, fire barriers, fire partitions or smoke barriers, or for load-bearing construction. Such blocks shall be erected with mortar and reinforcement in metal channel-type frames, structural frames, masonry or concrete recesses, embedded panel anchors as provided for both exterior and interior walls or other approved joint materials. Wood strip framing shall not be used in walls required to have a fire-resistance rating by other provisions of this Code.

Exceptions:

1. Glass-block assemblies having a fire protection rating of not less than 3/4 hour shall be permitted as opening protectives in accordance with Clause 716 in fire barriers, fire partitions and smoke barriers that have a required fire-resistance rating of 1 hour or less and do not enclose exit stairways and ramps or exit passageways.

3. Glass-block assemblies as permitted in Clause 4.4.6, Exception 2.

4.

22.11 MASONRY FIREPLACES

22.11.1 General.

The construction of masonry fireplaces, consisting of concrete or masonry, shall be in accordance with this clause.
22.11.2 Fireplace drawings.
The construction documents shall describe in sufficient detail the location, size and construction of masonry fireplaces. The thickness and characteristics of materials and the clearances from walls, partitions and ceilings shall be indicated.

22.11.3 Footings and foundations.
Footings for masonry fireplaces and their chimneys shall be constructed of concrete or solid masonry not less than 305 mm (12 inches) thick and shall extend not less than 153 mm (6 inches) beyond the face of the fireplace or foundation wall on all sides. Footings shall be founded on natural undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be not less than 305 mm (12 inches) below finished grade.

22.11.3.1 Ash dump cleanout.
Cleanout openings, located within foundation walls below fireboxes, where provided, shall be equipped with ferrous metal or masonry doors and frames constructed to remain tightly closed, except when in use. Clean outs shall be accessible and located so that ash removal will not create a hazard to combustible materials.

22.11.4 Seismic reinforcement.
In structures assigned to Seismic Design zone 0 or 1, seismic reinforcement is not required. In structures assigned to Seismic Design zone 2 and 3, masonry fireplaces shall be reinforced and anchored in accordance with Clauses 22.11.4.1, 22.11.4.2 and 22.11.5. In structures assigned to Seismic Design zone 3, masonry fireplaces shall be reinforced in accordance with the requirements of Clauses 22.1 through 22.8.

22.11.4.1 Vertical reinforcing.
For fireplaces with chimneys up to 1016 mm (40 inches) wide, four No. 4 continuous vertical bars, anchored in the foundation, shall be placed in the concrete between wythes of solid masonry or within the cells of hollow unit masonry and grouted in accordance with Clause 22.3.3. For fireplaces with chimneys greater than 1016 mm (40 inches) wide, two additional No. 4 vertical bars shall be provided for each additional 1016 mm (40 inches) in width or fraction thereof.

22.11.4.2 Horizontal reinforcing.
Vertical reinforcement shall be placed enclosed within 6.4 mm (1/4-inch) ties or other reinforcing of equivalent net cross-claimal area, spaced not to exceed 457 mm (18 inches) on center in concrete; or placed in the bed joints of unit masonry at not less than every 457 mm (18 inches) of vertical height. Two such ties shall be provided at each bend in the vertical bars.

22.11.5 Seismic anchorage.
Masonry fireplaces and foundations shall be anchored at each floor, ceiling or roof line more than 1829 mm (6 feet) above grade with two 4.8 mm by 25 mm (3/16-inch by 1-inch) straps embedded not less than 305 mm (12 inches) into the chimney. Straps shall be hooked around the outer bars and extend 152 mm (6 inches) beyond the bend. Each strap shall be fastened to not fewer than four floor joists with two 12.7 mm (1/2-inch) bolts.

Exception: Seismic anchorage is not required for the following:

1. In structures assigned to Seismic Design Category A or B.

2. Where the masonry fireplace is constructed completely within the exterior walls.

22.11.6 Firebox walls.
Masonry fireboxes shall be constructed of solid masonry units, hollow masonry units grouted solid, stone or concrete. Where a lining of firebrick not less than 51 mm (2 inches) in
thickness or other approved lining is provided, the minimum thickness of back and sidewalls shall each be 203 mm (8 inches) of solid masonry, including the lining. The width of joints between firebricks shall be not greater than 6.4 mm (1/4 inch). Where a lining is not provided, the total minimum thickness of back and sidewalls shall be 10 inches (254 mm) of solid masonry. Firebrick shall conform to ASTM C27 or ASTM C1261 and shall be laid with medium-duty refractory mortar conforming to ASTM C199.

22.11.6.1 Steel fireplace units.

Steel fireplace units are permitted to be installed with solid masonry to form a masonry fireplace provided that they are installed according to either the requirements of their listing or the requirements of this clause. Steel fireplace units incorporating a steel firebox lining shall be constructed with steel not less than 6.4 mm (1/4 inch) in thickness, and an air-circulating chamber that is ducted to the interior of the building. The firebox lining shall be encased with solid masonry to provide a total thickness at the back and sides of not less than 203 mm (8 inches), of which not less than 102 mm (4 inches) shall be of solid masonry or concrete. Circulating air ducts employed with steel fireplace units shall be constructed of metal or masonry.

22.11.7 Firebox dimensions.

The firebox of a concrete or masonry fireplace shall have a minimum depth of 508 mm (20 inches). The throat shall be not less than 203 mm (8 inches) above the fireplace opening. The throat opening shall be not less than 102 mm (4 inches) in depth. The cross-clauseal area of the passageway above the firebox, including the throat, damper and smoke chamber, shall be not less than the cross-clauseal area of the flue.

Exception: Rumford fireplaces shall be permitted provided that the depth of the fireplace is not less than 305 mm (12 inches) and not less than one-third of the width of the fireplace opening, and the throat is not less than 305 mm (12 inches) above the lintel, and not less than \(\frac{1}{20}\) the cross-clauseal area of the fireplace opening.

22.11.8 Lintel and throat.

Masonry over a fireplace opening shall be supported by a lintel of noncombustible material. The minimum required bearing length on each end of the fireplace opening shall be 102 mm (4 inches). The fireplace throat or damper shall be located not less than 203 mm (8 inches) above the top of the fireplace opening.

22.11.8.1 Damper.

Masonry fireplaces shall be equipped with a ferrous metal damper located not less than 203 mm (8 inches) above the top of the fireplace opening. Dampers shall be installed in the fireplace or at the top of the flue venting the fireplace, and shall be operable from the room containing the fireplace. Damper controls shall be permitted to be located in the fireplace.

22.11.9 Smoke chamber walls.

Smoke chamber walls shall be constructed of solid masonry units, hollow masonry units grouted solid, stone or concrete. The total minimum thickness of front, back and sidewalls shall be 203 mm (8 inches) of solid masonry. The inside surface shall be parged smooth with refractory mortar conforming to ASTM C199. Where a lining of firebrick not less than 2 inches (51 mm) thick, or a lining of vitrified clay not less than 15.9 mm (5/8 inch) thick, is provided, the total minimum thickness of front, back and sidewalls shall be 152 mm (6 inches) of solid masonry, including the lining. Firebrick shall conform to ASTM C1261 and shall be laid with refractory mortar conforming to ASTM C199. Vitrified clay linings shall conform to ASTM C315.

22.11.9.1 Smoke chamber dimensions.

The inside height of the smoke chamber from the fireplace throat to the beginning of the flue
shall be not greater than the inside width of the fireplace opening. The inside surface of the smoke chamber shall not be inclined more than 45 degrees (0.76 rad) from vertical where prefabricated smoke chamber linings are used or where the smoke chamber walls are rolled or sloped rather than corbeled. Where the inside surface of the smoke chamber is formed by corbeled masonry, the walls shall not be corbeled more than 30 degrees (0.52 rad) from vertical.

22.11.10 Hearth and hearth extension.

Masonry fireplace hearths and hearth extensions shall be constructed of concrete or masonry, supported by noncombustible materials, and reinforced to carry their own weight and all imposed loads. Combustible material shall not remain against the underside of hearths or hearth extensions after construction.

22.11.10.1 Hearth thickness.
The minimum thickness of fireplace hearths shall be 102 mm (4 inches).

22.11.10.2 Hearth extension thickness.
The minimum thickness of hearth extensions shall be 51 mm (2 inches).

Exception: Where the bottom of the firebox opening is raised not less than 203 mm (8 inches) above the top of the hearth extension, a hearth extension of not less than \( \frac{3}{8} \) -inch-thick (9.5 mm) brick, concrete, stone, tile or other approved noncombustible material is permitted.

22.11.11 Hearth extension dimensions.

Hearth extensions shall extend not less than 406 mm (16 inches) in front of, and not less than 203 mm (8 inches) beyond, each side of the fireplace opening. Where the fireplace opening is $0.557 m^2$ (6 square feet) or larger, the hearth extension shall extend not less than 508 mm (20 inches) in front of, and not less than 305 mm (12 inches) beyond, each side of the fireplace opening.

22.11.12 Fireplace clearance.

Any portion of a masonry fireplace located in the interior of a building or within the exterior wall of a building shall have a clearance to combustibles of not less than 51 mm (2 inches) from the front faces and sides of masonry fireplaces and not less than 102 mm (4 inches) from the back faces of masonry fireplaces. The airspace shall not be filled, except to provide fireblocking in accordance with Clause 22.11.13.

Exceptions:

1. Masonry fireplaces listed and labeled for use in contact with combustibles in accordance with this Code and installed in accordance with the manufacturer’s instructions are permitted to have combustible material in contact with their exterior surfaces.

2. Where masonry fireplaces are constructed as part of masonry or concrete walls, combustible materials shall not be in contact with the masonry or concrete walls less than 306 mm (12 inches) from the inside surface of the nearest firebox lining.

3. Exposed combustible trim and the edges of sheathing materials, such as wood siding, flooring and drywall, are permitted to abut the masonry fireplace sidewalls and hearth extension, in accordance with Figure 22.11.12, provided that such combustible trim or sheathing is not less than 306 mm (12 inches) from the inside surface of the nearest firebox lining.

4. Exposed combustible mantels or trim is permitted to be placed directly on the masonry fireplace front surrounding the fireplace opening, provided that such combustible materials shall not be placed within 153 mm (6 inches) of a fireplace opening. Combustible
material directly above and within 305 mm (12 inches) of the fireplace opening shall not project more than 3.2 mm (1/8 inch) for each 25 mm (1-inch) distance from such opening. Combustible materials located along the sides of the fireplace opening that project more than 38 mm (1 1/2 inches) from the face of the fireplace shall have an additional clearance equal to the projection.

For SI: 1 inch = 25.4 mm

**FIGURE 21.11.12 ILLUSTRATION OF EXCEPTION TO FIREPLACE CLEARANCE PROVISION**

22.11.13 Fireplace fireblocking.

All spaces between fireplaces and floors and ceilings through which fireplaces pass shall be fireblocked with noncombustible material securely fastened in place. The fireblocking of spaces between wood joists, beams or headers shall be to a depth of 25 mm (1 inch) and shall only be placed on strips of metal or metal lath laid across the spaces between combustible material and the chimney.

22.11.14 Exterior air.

Factory-built or masonry fireplaces covered in this clause shall be equipped with an exterior air supply to ensure proper fuel combustion unless the room is mechanically ventilated and controlled so that the indoor pressure is neutral or positive.

22.11.14.1 Factory-built fireplaces.

Exterior combustion air ducts for factory-built fireplaces shall be listed components of the fireplace, and installed according to the fireplace manufacturer's instructions.

22.11.14.2 Masonry fireplaces.

Listed combustion air ducts for masonry fireplaces shall be installed according to the terms of their listing and manufacturer's instructions.

22.11.14.3 Exterior air intake.

The exterior air intake shall be capable of providing all combustion air from the exterior of the dwelling. The exterior air intake shall not be located within a garage, attic, basement or crawl space of the dwelling nor shall the air intake be located at an elevation higher than the firebox. The exterior air intake shall be covered with a corrosion-resistant screen of 6.4 mm (1/4-inch) mesh.

21.11.14.4 Clearance.

Unlisted combustion air ducts shall be installed with a minimum 25 mm (1-inch) clearance to combustibles for all parts of the duct within 1524 mm (5 feet) of the duct outlet.

22.11.14.5 Passageway.

The combustion air passageway shall be not less than 3870 mm² (6 square inches) and not more than 0.035 m² (55 square inches), except that combustion air systems for listed fireplaces or for fireplaces tested for emissions shall be constructed according to the fireplace manufacturer's instructions.

22.11.14.6 Outlet

The exterior air outlet is permitted to be located in the back or sides of the firebox chamber or within 610 mm (24 inches) of the firebox opening on or near the floor. The outlet shall be closable.
and designed to prevent burning material from dropping into concealed combustible spaces.

22.12 MASONRY HEATERS

22.12.1 Definition.

A masonry heater is a heating appliance constructed of concrete or solid masonry, hereinafter referred to as “masonry,” which is designed to absorb and store heat from a solid fuel fire built in the firebox by routing the exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes flow in either a horizontal or downward direction before entering the chimney and which delivers heat by radiation from the masonry surface of the heater.

22.12.2 Installation.

Masonry heaters shall be installed in accordance with this clause and comply with one of the following:

1. Masonry heaters shall comply with the requirements of ASTM E1602.

2. Masonry heaters shall be listed and labeled in accordance with EN 15250 and installed in accordance with the manufacturer’s instructions.

22.12.3 Footings and foundation.

The firebox floor of a masonry heater shall be a minimum thickness of 102 mm (4 inches) of noncombustible material and be supported on a noncombustible footing and foundation in accordance with Clause 22.13.2.

22.12.4 Seismic reinforcing.

In structures assigned to Seismic Design Category D, E or F, masonry heaters shall be anchored to the masonry foundation in accordance with Clause 22.13.3. Seismic reinforcing shall not be required within the body of a masonry heater with a height that is equal to or less than 3.5 times its body width and where the masonry chimney serving the heater is not supported by the body of the heater. Where the masonry chimney shares a common wall with the facing of the masonry heater, the chimney portion of the structure shall be reinforced in accordance with Clause 22.13.

22.12.5 Masonry heater clearance.

Combustible materials shall not be placed within 914 mm (36 inches) or the distance of the allowed reduction method from the outside surface of a masonry heater in accordance with the Ghana fire Code, Clause 12.6, and the required space between the heater and combustible material shall be fully vented to permit the free flow of air around all heater surfaces.

Exceptions:

1. Where the masonry heater wall thickness is not less than 203 mm (8 inches) of solid masonry and the wall thickness of the heat exchange channels is not less than 127 mm (5 inches) of solid masonry, combustible materials shall not be placed within 102 mm (4 inches) of the outside surface of a masonry heater. A clearance of not less than 203 mm (8 inches) shall be provided between the gas-tight capping slab of the heater and a combustible ceiling.

2. Masonry heaters listed and labeled in accordance with EN 15250 and installed in accordance with the manufacturer’s instructions.

22.13 MASONRY CHIMNEYS

22.13.1 General.

The construction of masonry chimneys consisting of solid masonry units, hollow masonry units grouted solid, stone or concrete shall be in accordance with this clause.

22.13.2 Footings and foundations.

Footings for masonry chimneys shall be constructed of concrete or solid masonry not
less than 305 mm (12 inches) thick and shall extend not less than 152 mm (6 inches) beyond the face of the foundation or support wall on all sides. Footings shall be founded on natural undisturbed earth or engineered fill below frost depth. In areas not subjected to freezing, footings shall be not less than 305 mm (12 inches) below finished grade.

22.13.3 Seismic reinforcement.

In structures assigned to Seismic Design Category A or B, seismic reinforcement is not required. In structures assigned to Seismic Design Category C or D, masonry chimneys shall be reinforced and anchored in accordance with Clauses 22.13.3.1, 22.13.3.2 and 22.13.4. In structures assigned to Seismic Design Category E or F, masonry chimneys shall be reinforced in accordance with the requirements of Clauses 22.1 through 22.8 and anchored in accordance with Clause 22.13.4.

22.13.3.1 Vertical reinforcement.

For chimneys up to 1016 mm (40 inches) wide, four No. 4 continuous vertical bars anchored in the foundation shall be placed in the concrete between wythes of solid masonry or within the cells of hollow unit masonry and grouted in accordance with Clause 22.3.3. Grout shall be prevented from bonding with the flue liner so that the flue liner is free to move with thermal expansion. For chimneys greater than 1016 mm (40 inches) wide, two additional No. 4 vertical bars shall be provided for each additional 1016 mm (40 inches) in width or fraction thereof.

22.13.3.2 Horizontal reinforcement.

Vertical reinforcement shall be placed enclosed within 6.4 mm (1/4-inch) ties, or other reinforcing of equivalent net cross-clauseal area, spaced not to exceed 457 mm (18 inches) on center in concrete, or placed in the bed joints of unit masonry, at not less than every 457 mm (18 inches) of vertical height. Two such ties shall be provided at each bend in the vertical bars.

22.13.4 Seismic anchorage.

Masonry chimneys and foundations shall be anchored at each floor, ceiling or roof line more than 6 feet (1829 mm) above grade with two 4.8 mm by 25 mm (3/16-inch by 1-inch) straps embedded not less than 305 mm (12 inches) into the chimney. Straps shall be hooked around the outer bars and extend 152 mm (6 inches) beyond the bend. Each strap shall be fastened to not less than four floor joists with two 12.7 mm (1/2-inch) bolts.

Exception: Seismic anchorage is not required for the following:

1. In structures assigned to Seismic Design Category A or B.

2. Where the masonry fireplace is constructed completely within the exterior walls.

22.13.5 Corbeling.

Masonry chimneys shall not be corbeled more than half of the chimney’s wall thickness from a wall or foundation, nor shall a chimney be corbeled from a wall or foundation that is less than 305 mm (12 inches) in thickness unless it projects equally on each side of the wall, except that on the second storey of a two-storey dwelling, corbeling of chimneys on the exterior of the enclosing walls is permitted to equal the wall thickness. The projection of a single course shall not exceed one-half the unit height or one-third of the unit bed depth, whichever is less.

22.13.6 Changes in dimension.

The chimney wall or chimney flue lining shall not change in size or shape within 152 mm (6 inches) above or below where the chimney passes through floor components, ceiling components or roof components.
22.13.7 Offsets.
Where a masonry chimney is constructed with a fireclay flue liner surrounded by one wythe of masonry, the maximum offset shall be such that the centerline of the flue above the offset does not extend beyond the center of the chimney wall below the offset. Where the chimney offset is supported by masonry below the offset in an approved manner, the maximum offset limitations shall not apply. Each individual corbeled masonry course of the offset shall not exceed the projection limitations specified in Clause 22.13.5.

22.13.8 Additional load.
Chimneys shall not support loads other than their own weight unless they are designed and constructed to support the additional load. Masonry chimneys are permitted to be constructed as part of the masonry walls or concrete walls of the building.

22.13.9 Termination.
Chimneys shall extend not less than 610 mm (2 feet) higher than any portion of the building within 3048 mm (10 feet), but shall be not less than 914 mm (3 feet) above the highest point where the chimney passes through the roof.

22.13.9.1 Chimney caps.
Masonry chimneys shall have a concrete, metal or stone cap, sloped to shed water, a drip edge and a caulked bond break around any flue liners in accordance with ASTM C1283.

22.13.9.2 Spark arrestors.
Where a spark arrestor is installed on a masonry chimney, the spark arrestor shall meet all of the following requirements:

1. The net free area of the arrestor shall be not less than four times the net free area of the outlet of the chimney flue it serves.

2. The arrestor screen shall have heat and corrosion resistance equivalent to 19-gage galvanized steel or 24-gage stainless steel.

3. Openings shall not permit the passage of spheres having a diameter greater than 12.7 mm ( 1/2 inch) nor block the passage of spheres having a diameter less than 9.5 mm ( 3/8 inch).

4. The spark arrestor shall be accessible for cleaning and the screen or chimney cap shall be removable to allow for cleaning of the chimney flue.

22.13.9.3 Rain caps.
Where a masonry or metal rain cap is installed on a masonry chimney, the net free area under the cap shall be not less than four times the net free area of the outlet of the chimney flue it serves.

22.13.10 Wall thickness.
Masonry chimney walls shall be constructed of concrete, solid masonry units or hollow masonry units grouted solid with not less than 102 mm (4 inches) nominal thickness.

22.13.10.1 Masonry veneer chimneys.
Where masonry is used as veneer for a framed chimney, through flashing and weep holes shall be provided as required by Part 15.

22.13.11 Flue lining (material).
Masonry chimneys shall be lined. The lining material shall be appropriate for the type of appliance connected, according to the terms of the appliance listing and the manufacturer’s instructions.

22.13.11.1 Residential-type appliances (general).
Flue lining systems shall comply with one of the following:

1. Clay flue lining complying with the requirements of ASTM C315.

2. Listed chimney lining systems complying with this Code.

3. Factory-built chimneys or chimney units listed for installation within masonry chimneys.

4. Other approved materials that will resist corrosion, erosion, softening or cracking from flue gases and condensate at temperatures up to 1,800°F (982°C).

22.13.11.1.1 Flue linings for specific appliances.

Flue linings other than those covered in Clause 22.13.11.1 intended for use with specific appliances shall comply with Clauses 22.13.11.1.2 through 22.13.11.1.4, 22.13.11.2 and 22.13.11.3.

22.13.11.1.2 Gas appliances.

Flue lining systems for gas appliances shall be in accordance with the International Fuel Gas Code.

22.13.11.1.3 Pellet fuel-burning appliances.

Flue lining and vent systems for use in masonry chimneys with pellet fuel-burning appliances shall be limited to flue lining systems complying with Clause 22.13.11.1 and pellet vents listed for installation within masonry chimneys (see Clause 22.13.11.1.5 for marking).

22.13.11.1.4 Oil-fired appliances approved for use with L-vent.

Flue lining and vent systems for use in masonry chimneys with oil-fired appliances approved for use with Type L vent shall be limited to flue lining systems complying with Clause 22.13.11.1 and listed chimney liners complying with this Code (see Clause 22.13.11.1.5 for marking).

22.13.11.1.5 Notice of usage.

When a flue is relined with a material not complying with Clause 22.13.11.1, the chimney shall be plainly and permanently identified by a label attached to a wall, ceiling or other conspicuous location adjacent to where the connector enters the chimney. The label shall include the following message or equivalent language: “This chimney is for use only with (type or category of appliance) that burns (type of fuel). Do not connect other types of appliances.”

22.13.11.2 Concrete and masonry chimneys for medium-heat appliances.

Concrete and masonry chimneys for medium-heat appliances shall comply with Clauses 22.13.11.2.1 through 22.13.11.2.5.

22.13.11.2.1 Construction.

Chimneys for medium-heat appliances shall be constructed of solid masonry units or of concrete with walls not less than 203 mm (8 inches) thick, or with stone masonry not less than 305 mm (12 inches) thick.

22.13.11.2.2 Lining.

Concrete and masonry chimneys shall be lined with an approved medium-duty refractory brick not less than 114 mm (4 1/2 inches) thick laid on the 114 mm (4 1/2-inch bed) in an approved medium-duty refractory mortar. The lining shall start 610 mm (2 feet) or more below the lowest chimney connector entrance. Chimneys
terminating 7620 mm (25 feet) or less above a chimney connector entrance shall be lined to the top.

22.13.11.2.3 Multiple passageway.
Concrete and masonry chimneys containing more than one passageway shall have the liners separated by a minimum 102 mm (4-inch-thick) concrete or solid masonry wall.

22.13.11.2.4 Termination height.
Concrete and masonry chimneys for medium-heat appliances shall extend not less than 3048 mm (10 feet) higher than any portion of any building within 7620 mm (25 feet).

22.13.11.2.5 Clearance.
A minimum clearance of 102 mm (4 inches) shall be provided between the exterior surfaces of a concrete or masonry chimney for medium-heat appliances and combustible material.

22.13.11.3 Concrete and masonry chimneys for high-heat appliances.
Concrete and masonry chimneys for high-heat appliances shall comply with 22.13.11.3.1 through 22.13.11.3.4.

22.13.11.3.1 Construction.
Chimneys for high-heat appliances shall be constructed with double walls of solid masonry units or of concrete, each wall to be not less than 203 mm (8 inches) thick with a minimum airspace of 51 mm (2 inches) between the walls.

22.13.11.3.2 Lining.
The inside of the interior wall shall be lined with an approved high-duty refractory brick, not less than 114 mm (4 \( \frac{1}{2} \) inches) thick laid on the 114 mm bed (4 \( \frac{1}{2} \) - 1 inch) in an approved high-duty refractory mortar. The lining shall start at the base of the chimney and extend continuously to the top.

22.13.11.3.3 Termination height.
Concrete and masonry chimneys for high-heat appliances shall extend not less than 6096 mm (20 feet) higher than any portion of any building within 15 240 mm (50 feet).

22.13.11.3.4 Clearance.
Concrete and masonry chimneys for high-heat appliances shall have approved clearance from buildings and structures to prevent overheating combustible materials, permit inspection and maintenance operations on the chimney and prevent danger of burns to persons.

22.13.12 Clay flue lining (installation).
Clay flue liners shall be installed in accordance with ASTM C1283 and extend from a point not less than 203 mm (8 inches) below the lowest inlet or, in the case of fireplaces, from the top of the smoke chamber to a point above the enclosing walls. The lining shall be carried up vertically, with a maximum slope not greater than 30 degrees (0.52 rad) from the vertical.

Clay flue liners shall be laid in medium-duty nonwater-soluble refractory mortar conforming to ASTM C199 with tight mortar joints left smooth on the inside and installed to maintain an airspace or insulation not to exceed the thickness of the flue liner separating the flue liners from the interior face of the chimney masonry walls. Flue lining shall be supported on all sides. Only enough mortar shall be placed to make the joint and hold the liners in position.

22.13.13 Additional requirements.

22.13.13.1 Listed materials.
Listed materials used as flue linings shall be installed in accordance with the terms of their listings and the manufacturer’s instructions.
22.13.13.2 Space around lining.

The space surrounding a chimney lining system or vent installed within a masonry chimney shall not be used to vent any other appliance.

Exception: This shall not prevent the installation of a separate flue lining in accordance with the manufacturer’s instructions.

22.13.14 Multiple flues.

Where two or more flues are located in the same chimney, masonry wythes shall be built between adjacent flue linings. The masonry wythes shall be not less than 102 mm (4 inches) thick and bonded into the walls of the chimney.

Exception: Where venting only one appliance, two flues are permitted to adjoin each other in the same chimney with only the flue lining separation between them. The joints of the adjacent flue linings shall be staggered not less than 102 mm (4 inches).

22.13.15 Flue area (appliance).

Chimney flues shall not be smaller in area than the area of the connector from the appliance. Chimney flues connected to more than one appliance shall be not less than the area of the largest connector plus 50 percent of the areas of additional chimney connectors.

Exceptions:

1. Chimney flues serving oil-fired appliances sized in accordance with the Ghana Fire Code

2. Chimney flues serving gas-fired appliances sized in accordance with this Code

22.13.16 Flue area (masonry fireplace).

Flue sizing for chimneys serving fireplaces shall be in accordance with Clause 22.13.16.1 or 22.13.16.2.

For SI: 1 inch = 25.4 mm, 1 square inch = 645 mm$^2$. 
FIGURE 22.13.16
FLUE SIZES FOR MASONRY CHIMNEYS

TABLE 22.13.16(1) NET CROSS-CLAUSEAL AREA OF ROUND FLUE SIZES

<table>
<thead>
<tr>
<th>FLUE SIZE, INSIDE DIAMETER (inches)</th>
<th>CROSS-CLAUSEAL AREA (square inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>78</td>
</tr>
<tr>
<td>10 3/4</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>113</td>
</tr>
<tr>
<td>15</td>
<td>176</td>
</tr>
<tr>
<td>18</td>
<td>254</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm$^2$.

22.13.16.1 Minimum area.

Round chimney flues shall have a minimum net cross-clauseal area of not less than $\frac{1}{12}$ of the fireplace opening. Square chimney flues shall have a minimum net cross-clauseal area of not less than $\frac{1}{10}$ of the fireplace opening.

Rectangular chimney flues with an aspect ratio less than 2 to 1 shall have a minimum net cross-clauseal area of not less than $\frac{1}{10}$ of the fireplace opening. Rectangular chimney flues with an aspect ratio of 2 to 1 or more shall have a minimum net cross-clauseal area of not less than $\frac{1}{8}$ of the fireplace opening.

22.13.16.2 Determination of minimum area.

The minimum net cross-clauseal area of the flue shall be determined in accordance with Figure 22.13.16. A flue size providing not less than the equivalent net cross-clauseal area shall be used. Cross-clauseal areas of clay flue linings are as provided in Tables 22.13.16(1) and 22.13.16(2) or as provided by the manufacturer or as measured in the field. The height of the chimney shall be measured from the firebox floor to the top of the chimney flue.

22.13.17 Inlet.

Inlets to masonry chimneys shall enter from the side. Inlets shall have a thimble of fireclay, rigid refractory material or metal that will prevent the connector from pulling out of the inlet or from extending beyond the wall of the liner.
22.13.18 Masonry chimney cleanout openings.

Cleanout openings shall be provided within 6 inches (152 mm) of the base of each flue within every masonry chimney. The upper edge of the cleanout shall be located not less than 6 inches (152 mm) below the lowest chimney inlet opening. The height of the opening shall be not less than 6 inches (152 mm). The cleanout shall be provided with a noncombustible cover.

Exception: Chimney flues serving masonry fireplaces, where cleaning is possible through the fireplace opening.

22.13.19 Chimney clearances.

Any portion of a masonry chimney located in the interior of the building or within the exterior wall of the building shall have a minimum airspace clearance to combustibles of 51 mm (2 inches). Chimneys located entirely outside the exterior walls of the building, including chimneys that pass through the soffit or cornice, shall have a minimum airspace clearance of 25 mm (1 inch). The airspace shall not be filled, except to provide fireblocking in accordance with Clause 22.13.20.

Exceptions:

1. Masonry chimneys equipped with a chimney lining system listed and labeled for use in chimneys in contact with combustibles in accordance with this Code and installed in accordance with the manufacturer’s instructions, are permitted to have combustible material in contact with their exterior surfaces.

2. Where masonry chimneys are constructed as part of masonry or concrete walls, combustible materials shall not be in contact with the masonry or concrete wall less than 305 mm (12 inches) from the inside surface of the nearest flue lining.

3. Exposed combustible trim and the edges of sheathing materials, such as wood siding, are permitted to abut the masonry chimney sidewalls, in accordance with Figure 2113.19, provided that such combustible trim or sheathing is not less than 305 mm (12 inches) from the inside surface of the nearest flue lining. Combustible material and trim shall not overlap the corners of the chimney by more than 1 inch (25 mm).

22.14 MORTARLESS MASONRY


The design of mortarless masonry structures shall comply with the requirements of Parts 1 through 8 of TMS 402 except as modified by Clauses 22.14.2 through 22.14.5.

22.14.2 Limitations.

Mortarless masonry shall be prohibited in Risk Category IV structures.
Concrete masonry units complying with ASTM C90 shall be used.

22.14.4 Strength.
Mortarless masonry shall be of adequate strength and proportions to support all superimposed loads without exceeding the allowable stresses listed in Table 2114.4. Allowable stresses not specified in Table 2114.4 shall comply with the requirements of Part 8 of TMS 402.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MAXIMUM ALLOWABLE STRESS (psl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>45</td>
</tr>
<tr>
<td>Flexural tension</td>
<td></td>
</tr>
<tr>
<td>Horizontal span</td>
<td>30</td>
</tr>
<tr>
<td>Vertical span</td>
<td>18</td>
</tr>
<tr>
<td>Shear</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: For SI: 1 pound per square inch = 0.006895 MPa.

22.14.5 Construction.
Construction of mortarless masonry shall comply with ASTM C946.
PART 23: STEEL

User notes:
About this part: Part 23 provides the minimum requirements for the design and construction of structural steel (including composite construction), cold-formed steel, steel joists, steel cable structures and steel storage racks. This part specifies appropriate design and construction standards for these types of structures. It also provides a road map of the applicable technical requirements for steel structures. Part 23 requires that the design and use of steel structures and components be in accordance with the applicable specifications and standards of Ghana Standards Authority.

23.1 GENERAL

23.1.1 Scope.
The provisions of this part cover the quality, design, fabrication and use of steel construction.

23.2 IDENTIFICATION OF STEEL FOR STRUCTURAL PURPOSES

23.2.1 General.
Identification of structural steel elements shall be in accordance with AISC 360. Identification of cold-formed steel members shall be in accordance with AISI S100. Identification of cold-formed steel light-frame construction shall also comply with the requirements contained in AISI S240 or AISI S220, as applicable. Other steel furnished for structural load-carrying purposes shall be properly identified for conformity to the ordered grade in accordance with the specified ASTM standard or other specification and the provisions of this part. Where the steel grade is not readily identifiable from marking and test records, the steel shall be tested to verify conformity to such standards.

23.3 PROTECTION OF STEEL FOR STRUCTURAL PURPOSES

23.3.1 General.
Painting of structural steel elements shall be in accordance with AISC 360. Painting of open-web steel joists and joist girders shall be in accordance with SJI CJ and SJI 100. Individual structural members and assembled panels of cold-formed steel construction shall be protected against corrosion in accordance with the requirements contained in AISI S100. Protection of cold-formed steel light-frame construction shall be in accordance with AISI S240 or AISI S220, as applicable.

23.4 CONNECTIONS

23.4.1 Welding.
The details of design, workmanship and technique for welding and qualification of welding personnel shall be in accordance with the specifications listed in Clauses 23.5, 23.6, 23.7, 23.8, 23.10 and 23.11. For special inspection of welding, see Clause 19.5.2.

23.4.2 Bolting.
The design, installation and inspection of bolts shall be in accordance with the requirements of Clauses 23.5, 23.6, 23.7, 23.10 and 23.11. For special inspection of the installation of high-strength bolts, see Clause 19.5.2.

23.4.3 Anchor rods.
Anchor rods shall be set in accordance with the approved construction documents. The protrusion of the threaded ends through the connected material shall fully engage the threads of the nuts but shall not be greater than the length of the threads on the bolts.

23.5 STRUCTURAL STEEL

23.5.1 General.
The design, fabrication and erection of structural steel elements in buildings, structures and portions thereof shall be in accordance with AISC 360.

23.5.2 Seismic design.
Where required, the seismic design, fabrication and erection of buildings, structures and portions thereof shall be in accordance with Clause 23.5.2.1 or 23.5.2.2, as applicable.
23.5.2.1 Structural steel seismic force-resisting systems.

The design, detailing, fabrication and erection of structural steel seismic force-resisting systems shall be in accordance with the provisions of Clauses 23.5.2.1.1 or 23.5.2.1.2, as applicable.

23.5.2.1.1 Seismic Design Zones 1 or 2

Structures assigned to Seismic Design Zones 1 or 2 shall be of any construction permitted in Clause 23.5. Where a response modification coefficient, R, in accordance with ASCE 7, Table 12.2-1, is used for the design of structures assigned to Seismic Design Zones 1 or 2, the structures shall be designed and detailed in accordance with the requirements of AISC 341.

Exception: The response modification coefficient, R, designated for “Steel systems not specifically detailed for seismic resistance, excluding cantilever column systems” in ASCE 7, Table 12.2-1, shall be permitted for systems designed and detailed in accordance with AISC 360, and need not be designed and detailed in accordance with AISC 341.

23.5.2.1.2 Seismic Design Zone 3.

Structures assigned to Seismic Design Zone 3 shall be designed and detailed in accordance with AISC 341, except as permitted in ASCE 7, Table 15.4-1.

23.5.2.2 Structural steel elements.

The design, detailing, fabrication and erection of structural steel elements in seismic force-resisting systems other than those covered in Clause 23.5.2.1, including struts, collectors, chords and foundation elements, shall be in accordance with AISC 341 where either of the following applies:

1. The structure is assigned to Seismic Design Zone 3, except as permitted in ASCE 7, Table 15.4-1.

2. A response modification coefficient, R, greater than 3 in accordance with ASCE 7, Table 12.2-1, is used for the design of the structure assigned to Seismic Design Zone 1 or 2.

23.6 COMPOSITE STRUCTURAL STEEL AND CONCRETE STRUCTURES

23.6.1 General.


23.6.2 Seismic design.

Where required, the seismic design, fabrication and erection of composite steel and concrete systems shall be in accordance with Clause 23.6.2.1.

23.6.2.1 Seismic requirements for composite structural steel and concrete construction.

Where a response modification coefficient, R, in accordance with ASCE 7, Table 12.2-1, is used for the design of systems of structural steel acting compositely with reinforced concrete, the structures shall be designed and detailed in accordance with the requirements of AISC 341.

23.7 STEEL JOISTS

23.7.1 General.

The design, manufacture and use of open-web steel joists and joist girders shall be in accordance with either SJI CJ or SJI 100, as applicable.

23.7.1.1 Seismic design.

Where required, the seismic design of buildings shall be in accordance with the additional provisions of Clause 23.5.2 or 23.11.1.1.

23.7.2 Design.

The registered design professional shall indicate on the construction documents the steel joist and steel joist girder designations from the specifications listed in Clause 23.7.1; and shall indicate the requirements for joist and joist girder design, layout, end supports, anchorage,
bridging design that differs from the SJI specifications listed in Clause 23.7.1, bridging termination connections and bearing connection design to resist uplift and lateral loads. These documents shall indicate special requirements as follows:

1. Special loads including:
   1.1. Concentrated loads.
   1.2. Nonuniform loads.
   1.3. Net uplift loads.
   1.4. Axial loads.
   1.5. End moments.
   1.6. Connection forces.

2. Special considerations including:
   2.1. Profiles for joist and joist girder configurations that differ from those defined by the SJI specifications listed in Clause 23.7.1.
   2.2. Oversized or other nonstandard web openings.
   2.3. Extended ends.

3. Live and total load deflection criteria for joists and joist girder configurations that differ from those defined by the SJI specifications listed in Clause 23.7.1.

23.7.3 Calculations.
The steel joist and joist girder manufacturer shall design the steel joists and steel joist girders in accordance with the SJI specifications listed in Clause 23.7.1 to support the load requirements of Clause 23.7.2. The registered design professional shall be permitted to require submission of the steel joist and joist girder calculations as prepared by a registered design professional responsible for the product design. Where requested by the registered design professional, the steel joist manufacturer shall submit design calculations with a cover letter bearing the seal and signature of the joist manufacturer's registered design professional. In addition to the design calculations submitted under seal and signature, the following shall be included:

1. Bridging design that differs from the SJI specifications listed in Clause 23.7.1, such as cantilevered conditions and net uplift.

2. Connection design for:
   2.1. Connections that differ from the SJI specifications listed in Clause 23.7.1, such as flush-framed or framed connections.
   2.2. Field splices.
   2.3. Joist headers.

23.7.4 Steel joist drawings.
Steel joist placement plans shall be provided to show the steel joist products as specified on the approved construction documents and are to be utilized for field installation in accordance with specific project requirements as stated in Clause 23.7.2. Steel joist placement plans shall include, at a minimum, the following:

1. Listing of applicable loads as stated in Clause 23.7.2 and used in the design of the steel joists and joist girders as specified in the approved construction documents.
2. Profiles for joist and joist girder configurations that differ from those defined by the SJI specifications listed in Clause 23.7.1.

3. Connection requirements for:
   3.1. Joist supports.
   3.2. Joist girder supports.
   3.3. Field splices.
   3.4. Bridging attachments.

4. Live and total load deflection criteria for joists and joist girder configurations that differ from those defined by the SJI specifications listed in Clause 23.7.1.

5. Size, location and connections for bridging.


   Steel joist placement plans do not require the seal and signature of the joist manufacturer’s registered design professional.

23.7.5 Certification.

At completion of manufacture, the steel joist manufacturer shall submit a certificate of compliance to the owner or the owner’s authorized agent for Submission to the Head of Works department as specified in Clause 17.4.5 stating that work was performed in accordance with approved construction documents and with SJI specifications listed in Clause 23.7.1.

23.8 STEEL CABLE STRUCTURES

23.8.1 General.

The design, fabrication and erection including related connections, and protective coatings of steel cables for buildings shall be in accordance with ASCE 19.

23.9 STEEL STORAGE RACKS

23.9.1 Storage racks.

The design, testing and utilization of storage racks made of cold-formed or hot-rolled steel structural members shall be in accordance with RMI ANSI/MH 16.1. Where required by ASCE 7, the seismic design of storage racks shall be in accordance with Clause 15.5.3 of ASCE 7.

23.9.2 Cantilevered steel storage racks.

The design, testing, and utilization of cantilevered storage racks made of cold-formed or hot-rolled steel structural members shall be in accordance with RMI ANSI/MH 16.3. Where required by ASCE 7, the seismic design of cantilevered steel storage racks shall be in accordance with Clause 15.5.3 of ASCE 7.

23.10 COLD-FORMED STEEL

23.10.1 General.

The design of cold-formed carbon and low-alloy steel structural members shall be in accordance with AISI S100. The design of cold-formed stainless-steel structural members shall be in accordance with ASCE 8. Cold-formed steel light-frame construction shall comply with Clause 23.11. Where required, the seismic design of cold-formed steel structures shall be in accordance with the additional provisions of Clause 23.10.2.

23.10.1.1 Steel decks.

The design and construction of cold-formed steel decks shall be in accordance with this clause.

23.10.1.1.1 Noncomposite steel floor decks.

Noncomposite steel floor decks shall be permitted to be designed and constructed in accordance with ANSI/SDI-NC1.0.
23.10.1.2 Steel roof deck.
Steel roof decks shall be permitted to be designed and constructed in accordance with ANSI/SDI-RD1.0.

23.10.1.3 Composite slabs on steel decks.
Composite slabs of concrete and steel deck shall be permitted to be designed and constructed in accordance with SDI-C.

23.10.2 Seismic requirements for cold-formed steel structures.
Where a response modification coefficient, R, in accordance with ASCE 7, Table 12.2-1, is used for the design of cold-formed steel structures, the structures shall be designed and detailed in accordance with the requirements of AISI S100, ASCE 8, or, for cold-formed steel special-bolted moment frames, AISI S400.

23.11 COLD-FORMED STEEL LIGHT-FRAME CONSTRUCTION

23.11.1 Structural framing.
For cold-formed steel light-frame construction, the design and installation of the following structural framing systems, including their members and connections, shall be in accordance with AISI S240, and Clauses 23.11.1.1 through 23.11.1.3, as applicable:

1. Floor and roof systems.
2. Structural walls.
3. Shear walls, strap-braced walls and diaphragms that resist in-plane lateral loads.
4. Trusses.

23.11.1.1 Seismic requirements for cold-formed steel structural systems.
The design of cold-formed steel light-frame construction to resist seismic forces shall be in accordance with the provisions of Clause 23.11.1.1.1 or 23.11.1.1.2, as applicable.

23.11.1.1.1 Seismic Design Zone 1 or 2
Where a response modification coefficient, R, in accordance with ASCE 7, Table 12.2-1 is used for the design of cold-formed steel light-frame construction assigned to Seismic Design Zone 1 or 2 the seismic force-resisting system shall be designed and detailed in accordance with the requirements of AISI S400.

Exception: The response modification coefficient, R, designated for “Steel systems not specifically detailed for seismic resistance, excluding cantilever column systems” in ASCE 7, Table 12.2-1, shall be permitted for systems designed and detailed in accordance with AISI S240 and need not be designed and detailed in accordance with AISI S400.

23.11.1.1.2 Seismic Design Categories D through F.
In cold-formed steel light-frame construction assigned to Seismic Design Zone 3, the seismic force-resisting system shall be designed and detailed in accordance with AISI S400.

23.11.1.2 Prescriptive framing.
Detached one- and two-family dwellings and townhouses, less than or equal to three stories above grade plane, shall be permitted to be constructed in accordance with AISI S230 subject to the limitations therein.

23.11.1.3 Truss design.
Cold-formed steel trusses shall comply with the additional provisions of Clauses 23.11.1.3.1. through 23.11.1.3.3.

23.11.1.3.1 Truss design drawings.
The truss design drawings shall conform to the requirements of Clause I1 of AISI S202 and shall be provided with the shipment of trusses delivered to the job site. The truss design drawings shall include the details of permanent individual truss member restraint/bracing in accordance with Clause II.6 of AISI S202 where these methods are utilized to provide restraint/bracing.
23.11.1.3.2 Trusses spanning 60 feet or greater.
The owner or the owner’s authorized agent shall contract with a registered design professional for the design of the temporary installation restraint/bracing and the permanent individual truss member restraint/bracing for trusses with clear spans 18 288 mm (60 feet) or greater. Special inspection of trusses over 18 288 mm (60 feet) in length shall be in accordance with Clause 19.5.2.

23.11.1.3.3 Truss quality assurance.
Trusses not part of a manufacturing process that provides requirements for quality control done under the supervision of a third-party quality control agency in accordance with AISI S240 Part D shall be fabricated in compliance with Clauses 19.4.2.5 and 190.5.2, as applicable.

23.11.2 Nonstructural members.
For cold-formed steel light-frame construction, the design and installation of nonstructural members and connections shall be in accordance with AISI S220.

23.12 Steel and its Alloys
a) General
GS IS: 1030 Carbon steel castings for general engineering purposes
GS IS: 1136 Preferred sizes for wrought metal products.
GS IS: 1137 Thickness of sheet and diameters of wire
GS IS: 1762 Code for designation of steels
GS IS: 2049 Colour Code for the identification of wrought steel for general engineering purposes
GS IS: 2644 High tensile steel castings
GS IS: 7598 Classification of steels

b) Structural Steel
GS IS: 1977 Specification for low tensile structural steels
GS IS: 2062 Specification for steel for general structural purposes
GS IS: 2830 Specification for carbon steel billets ingots, blooms and slabs for re-rolling into steel for general structural purposes
GS IS: 2831 Specification for steel ingots and billets for the production of steel wire for the manufacture of wood screws
GS IS: 8500 Specification for structural steels microalloyed (medium and high strength qualities).
GS IS: 8952 Steel ingots, blooms and billets for production of mild steel wire rods for general engineering purposes.

c) Sheet and Strip
GS IS: 277 Specification for galvanized steel sheets (plain and corrugated)
GS IS: 412 Specification for expanded metal steel sheets for general purposes
GS IS: 513 Specification for cold rolled low carbon steel sheets and strips
GS IS: 1079 Specification for hot rolled carbon steel sheet and strip
GS IS: 6911 Stainless steel plate, sheet and strip
GS IS: 7226 Specification for cold rolled medium, high carbon and low alloy steel strip for general engineering purposes.
GS IS: 11587 Specification for structural weather resistant steel
GS IS: 14246 Specification for continuously pre-painted galvanized steel sheets and coils
GS IS: 15103 Specification for fire resistant steel

d) Bars, Rods, Wire and Wire Rods
GS IS: 280 Specification for mild steel wire for general engineering purposes

GS IS: 1148 Specification for hot rolled steel rivet bars (up to 40 mm diameter) for structural purposes.

GS IS: 1148 Specification for high tensile steel rivet bars for structural purposes

GS IS: 1673 Specification for mild steel wire cold heading quality.

GS IS: 1812 Specification for carbon steel wire for the manufacture of wood screw

GS IS: 1835 Specification for round steel wire for ropes

GS IS: 2591 Dimensions for hot rolled bars for threaded components

GS IS: 3150 Specification for hexagonal wire netting for general purposes

GS IS: 4826 Specification for hot-dipped galvanized coatings on round steel wires

GS IS: 6527 Stainless steel wire rod

GS IS: 6528 Specification for stainless steel wire

GS IS: 6603 Specification for stainless steel bars and flats

GS IS: 7887 Specification for mild steel wire rods for general engineering purposes

GS IS: 10631 Stainless steel for welding electrode core wire

e) Plates

GS IS: 3502 Specification for steel chequered plates

f) Tubes and Tubulars

GS IS: 1161 Specification for steel tubes for structural purposes

GS IS: 4516 Specification for elliptical mild steel tubes

GS IS: 4923 Specification for hollow mild steel clauses for structural use

g) Splotted Clauses

GS IS: 8081 Specification for splotted clauses
PART 24: WOOD, BAMBOO AND RATTAN

User notes:

About this part: Part 24 provides minimum requirements for the design of buildings and structures that use wood and wood-based products. The part is organized around three design methodologies: allowable stress design (ASD), load and resistance factor design (LRFD) and conventional light-frame construction. Included in the part are references to design and manufacturing standards for various wood and wood-based products; general construction requirements; design criteria for lateral force-resisting systems and specific requirements for the application of the three design methods.

24.1 GENERAL

24.1.1 Scope.
The provisions of this part shall govern the materials, design, construction and quality of wood members and their fasteners.

24.1.2 Nominal sizes.
For the purposes of this part, where dimensions of timber are specified, they shall be deemed to be nominal dimensions unless specifically designated as actual dimensions (see Clause 24.4.2).

24.2 DESIGN REQUIREMENTS

24.2.1 General.
The design of structural elements or systems, constructed partially or wholly of wood or wood-based products, shall be in accordance with one of the following methods:

1. Allowable stress design in accordance with Clauses 24.4, 24.5 and 24.6.

2. Load and resistance factor design in accordance with Clauses 24.4, 24.5 and 24.7.

3. Conventional light-frame construction in accordance with Clauses 24.4 and 24.8.

5. The design and construction of log structures in accordance with the provisions of GS 1190.

24.3 MINIMUM STANDARDS AND QUALITY

24.3.1 General.
Structural sawn timber; end-jointed timber; prefabricated wood I-joists; structural glued-laminated timber; wood structural panels; fibreboard sheathing (where used structurally); hardboard siding (where used structurally); particleboard; preservative-treated wood; structural log members; structural composite timber; round timber poles and piles; fire-retardant-treated wood; hardwood plywood; wood trusses; joist hangers; nails; and staples shall conform to the applicable provisions of this clause.

24.3.1.1 Sawn timber.
Sawn timber used for load-supporting purposes, including end-jointed or edge-glued timber, machine stress-rated or machine-evaluated timber, shall be identified by the grade mark of a timber grading or inspection agency that has been approved by an accreditation body. Grading practices and identification shall comply with rules published by an agency approved in accordance with the procedures of Timber Industry Development Directorate (TIDD) or equivalent procedures.

24.3.1.1.1 Certificate of inspection.
In lieu of a grade mark on the material, a certificate of inspection as to species and grade issued by a timber grading or inspection agency meeting the requirements of this clause is permitted to be accepted for precut, remanufactured or rough-sawn timber and for sizes larger than 76 mm (3 inches) nominal thickness.

24.3.1.2 End-jointed timber.
Approved end-jointed timber is permitted to be used interchangeably with solid-sawn members.
of the same species and grade. End-jointed timber used in an assembly required to have a fire-resistance rating shall have the designation “Heat Resistant Adhesive” or “HRA” included in its grade mark.

24.3.1.2 Prefabricated wood I-joists.
Structural capacities and design provisions for prefabricated wood I-joists shall be established and monitored in accordance with ASTM D5055.

24.3.1.3 Structural glued-laminated timber.
Glued-laminated timbers shall be manufactured and identified as required in ASTM D3737.

24.3.1.4 Structural glued cross-laminated timber.
Cross-laminated timbers shall be manufactured and identified in accordance with ASTM D3737.

24.3.1.5 Wood structural panels.
Wood structural panels, where used structurally (including those used for siding, roof and wall sheathing, subflooring, diaphragms and built-up members), shall conform to the requirements of GS EN 312. Each panel or member shall be identified for grade, bond classification, and Performance Category by the trademarks of an approved testing and grading agency. The Performance Category value shall be used as the “nominal panel thickness” or “panel thickness” whenever referenced in this Code. Wood structural panel components shall be designed and fabricated in accordance with the applicable standards listed in Clause 24.6.1 and identified by the trademarks of an approved testing and inspection agency indicating conformance to the applicable standard. In addition, wood structural panels where permanently exposed in outdoor applications shall be of exterior type, except that wood structural panel roof sheathing exposed to the outdoors on the underside is permitted to be Exposure 1 type.

24.3.1.6 Fibreboard.
Fibreboard for its various uses shall conform to ASTM C208. Fibreboard sheathing, where used structurally, shall be identified by an approved agency as conforming to ASTM C208.

24.3.1.6.1 Jointing.
To ensure tight-fitting assemblies, edges shall be manufactured with square, shiplapped, beveled, tongue-and-groove or U-shaped joints.

24.3.1.6.2 Roof insulation.
Where used as roof insulation in all types of construction, fibreboard shall be protected with an approved roof covering.

24.3.1.6.3 Wall insulation.
Where installed and fire-blocked to comply with this Code, fibreboards are permitted as wall insulation in all types of construction. In fire walls and fire barriers, unless treated to comply with Clause 9.3.1 for Class A materials, the boards shall be cemented directly to the concrete, masonry or other noncombustible base and shall be protected with an approved noncombustible veneer anchored to the base without intervening airspaces.

24.3.1.6.3.1 Protection.
Fibreboard wall insulation applied on the exterior of foundation walls shall be protected below ground level with a bituminous coating.

24.3.1.7 Hardboard.
Hardboard siding shall conform to the requirements of GS 1029 and, where used structurally, shall be identified by the label of an approved agency. Hardboard underlayment shall meet the strength requirements of 5.6 mm (7/32-inch) or 6.4 mm (1/4-inch) service class hardboard planed or sanded on one side to a uniform thickness of not less than 5.1 mm (0.200 inch). Prefinished hardboard paneling shall meet the requirements of GS 1029. Other basic hardboard products shall meet the requirements of GS 1029. Hardboard products shall be
installed in accordance with manufacture’s recommendations.

24.3.1.8 Particleboard.

Particleboard shall conform to GS EN 312. Particleboard shall be identified by the grade mark or certificate of inspection issued by an approved agency. Particleboard shall not be utilized for applications other than indicated in this clause unless the particleboard complies with the provisions of Clause 24.6.3.

24.3.1.8.1 Floor underlayment.

Particleboard floor underlayment shall conform to GS EN 312. Type PBU underlayment shall be not less than 6.4 mm (1/4-inch) thick and shall be installed in accordance with the manufacturer’s instructions.

24.3.1.9 Preservative-treated wood.

Timber, plywood, piles and poles supporting permanent structures required by Clause 24.4.12 to be preservative treated shall conform to GS 146-1 and 2. Timber and plywood used in permanent wood foundation systems shall conform to Part 18.

24.3.1.9.1 Identification.

Wood required by Clause 24.4.12 to be preservative treated shall bear the quality mark of an inspection agency that maintains continuing supervision, testing and inspection over the quality of the preservative-treated wood. Inspection agencies for preservative-treated wood shall be listed by an accreditation body that complies with the requirements of the Ghana Standards Treated Wood Program or equivalent. The quality mark shall be on a stamp or label affixed to the preservative-treated wood, and shall include the following information:

1. Identification of treating manufacturer.
2. Type of preservative used.
3. Minimum preservative retention (pcf).
4. End use for which the product is treated.
5. Ghana standard to which the product was treated.
6. Identity of the accredited inspection agency.

24.3.1.9.2 Moisture content.

Where preservative-treated wood is used in enclosed locations where drying in service cannot readily occur, such wood shall be at a moisture content of 19 percent or less before being covered with insulation, interior wall finish, floor covering or other materials.

24.3.1.10 Structural composite timber.

Structural capacities for structural composite timber shall be established and monitored in accordance with ASTM D5456.

24.3.1.11 Structural log members.

Stress grading of structural log members of nonrectangular shape, as typically used in log buildings, shall be in accordance with ASTM D3957. Such structural log members shall be identified by the grade mark of an approved timber grading or inspection agency. In lieu of a grade mark on the material, a certificate of inspection as to species and grade issued by a timber grading or inspection agency meeting the requirements of this clause shall be permitted.

24.3.1.12 Round timber poles and piles.

Round timber poles and piles shall comply with ASTM D3200 and ASTM D25, respectively.

24.3.1.13 Engineered wood rim board.

Engineered wood rim boards shall be evaluated in accordance with ASTM D7672. Structural capacities shall be in accordance with ASTM D7672 or established in accordance with ASTM D7672. Rim boards conforming to ASTM D7672 shall be marked in accordance with that standard.
24.3.2 Fire-retardant-treated wood.

Fire-retardant-treated wood is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E84, a listed flame spread index of 25 or less and show no evidence of significant progressive combustion when the test is continued for an additional 20-minute period. Additionally, the flame front shall not progress more than 3200 mm (10\(\frac{1}{2}\) feet) beyond the centerline of the burners at any time during the test.

24.3.2.1 Pressure process.

For wood products impregnated with chemicals by a pressure process, the process shall be performed in closed vessels under pressures not less than 50 pounds per square inch gauge (psig) (345 kPa).

24.3.2.2 Other means during manufacture.

For wood products impregnated with chemicals by other means during manufacture, the treatment shall be an integral part of the manufacturing process of the wood product. The treatment shall provide permanent protection to all surfaces of the wood product. The use of paints, coating, stains or other surface treatments is not an approved method of protection as required in this clause.

24.3.2.3 Testing.

For wood products produced by other means during manufacture, other than a pressure process, all sides of the wood product shall be tested in accordance with and produce the results required in Clause 24.3.2. Wood structural panels shall be permitted to test only the front and back faces.

24.3.2.4 Labeling.

In addition to the labels required in Clause 24.3.1.1 for sawn timber and Clause 24.3.1.5 for wood structural panels, each piece of fire-retardant-treated timber and wood structural panels shall be labeled. The label shall contain the following items:

1. The identification mark of an approved agency in accordance with Clause 19.3.5.

2. Identification of the treating manufacturer.

3. The name of the fire-retardant treatment.

4. The species of wood treated.

5. Flame spread and smoke-developed index.


7. Conformance with appropriate standards in accordance with Clauses 24.3.2.5 through 2303.2.8.

8. For fire-retardant-treated wood exposed to weather, damp or wet locations, include the words “No increase in the listed classification when subjected to the Standard Rain Test” (ASTM D2898).

24.3.2.5 Strength adjustments.

Design values for untreated timber and wood structural panels, as specified in Clause 24.3.1, shall be adjusted for fire-retardant-treated wood. Adjustments to design values shall be based on an approved method of investigation that takes into consideration the effects of the anticipated temperature and humidity to which the fire-retardant-treated wood will be subjected, the type of treatment and redrying procedures.

24.3.2.5.1 Wood structural panels.

The effect of treatment and the method of redrying after treatment, and exposure to high temperatures and high humidities on the flexure properties of fire-retardant-treated softwood plywood shall be determined in accordance with ASTM D5516. The test data developed by
ASTM D5516 shall be used to develop adjustment factors, maximum loads and spans, or both, for untreated plywood design values in accordance with ASTM D6305. Each manufacturer shall publish the allowable maximum loads and spans for service as floor and roof sheathing for its treatment.

24.3.2.5.2 Timber.

For each species of wood that is treated, the effects of the treatment, the method of redrying after treatment and exposure to high temperatures and high humidity on the allowable design properties of fire-retardant-treated timber shall be determined in accordance with ASTM D5664. The test data developed by ASTM D5664 shall be used to develop modification factors for use at or near room temperature and at elevated temperatures and humidity in accordance with ASTM D6841. Each manufacturer shall publish the modification factors for service at temperatures of not less than 25°C (80°F) and for roof framing. The roof framing modification factors shall take into consideration the climatological location.

24.3.2.6 Exposure to weather, damp or wet locations.

Where fire-retardant-treated wood is exposed to weather, or damp or wet locations, it shall be identified as “Exterior” to indicate there is no increase in the listed flame spread index as defined in Clause 24.3.2 when subjected to ASTM D2898.

24.3.2.7 Interior applications.

Interior fire-retardant-treated wood shall have moisture content of not over 28 percent when tested in accordance with ASTM D3201 procedures at 85-percent relative humidity. Interior fire-retardant-treated wood shall be tested in accordance with Clause 24.3.2.5.1 or 24.3.2.5.2.

24.3.2.8 Moisture content.

Fire-retardant-treated wood shall be dried to a moisture content of 19 percent or less for timber and 15 percent or less for wood structural panels before use. For wood kiln-dried after treatment (KDAT), the kiln temperatures shall not exceed those used in kiln drying the timber and plywood submitted for the tests described in Clause 24.3.2.5.1 for plywood and 24.3.2.5.2 for timber.

24.3.2.9 Type I construction applications.

See Clause 7.3.1 for limitations on the use of fire-retardant-treated wood in buildings of Type I.

24.3.3 Hardwood and plywood.

Hardwood and decorative plywood shall be manufactured and identified as required in GS 1029 and GS 198.

24.3.4 Trusses.

Wood trusses shall comply with Clauses 24.3.4.1 through 24.3.4.7.

24.3.4.1 Design.

Wood trusses shall be designed in accordance with the provisions of this Code and accepted engineering practice. Members are permitted to be joined by nails, glue, bolts, timber connectors, metal connector plates or other approved framing devices.

24.3.4.1.1 Truss design drawings.

The written, graphic and pictorial depiction of each individual truss shall be provided to the Head of Works department for approval prior to installation. Truss design drawings shall be provided with the shipment of trusses delivered to the job site. Truss design drawings shall include, at a minimum, the following information:

1. Slope or depth, span and spacing.
2. Location of all joints and support locations.
3. Number of plies if greater than one.
4. Required bearing widths.
5. Design loads as applicable, including:
5.1. Top chord live load.

5.2. Top chord dead load.

5.3. Bottom chord live load.

5.4. Bottom chord dead load.

5.5. Additional loads and locations.

5.6. Environmental design criteria and loads (such as wind, rain, seismic).

6. Other lateral loads, including drag strut loads.

7. Adjustments to wood member and metal connector plate design value for conditions of use.

8. Maximum reaction force and direction, including maximum uplift reaction forces where applicable.

9. Joint connection type and description, such as size and thickness or gage, and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.

10. Size, species and grade for each wood member.

11. Truss-to-truss connections and truss field assembly requirements.

12. Calculated span-to-deflection ratio and maximum vertical and horizontal deflection for live and total load as applicable.

13. Maximum axial tension and compression forces in the truss members.

14. Required permanent individual truss member restraint location and the method and details of restraint/bracing to be used in accordance with Clause 24.3.4.1.2.

24.3.4.1.2 Permanent individual truss member restraint.

Where permanent restraint of truss members is required on the truss design drawings, it shall be accomplished by one of the following methods:

1. Permanent individual truss member restraint/bracing shall be installed using standard industry lateral restraint/bracing details in accordance with generally accepted engineering practice. Locations for lateral restraint shall be identified on the truss design drawing.

2. The trusses shall be designed so that the buckling of any individual truss member is resisted internally by the individual truss through suitable means (for example, buckling reinforcement by T-reinforcement or L-reinforcement, proprietary reinforcement). The buckling reinforcement of individual members of the trusses shall be installed as shown on the truss design drawing or on supplemental truss member buckling reinforcement details provided by the truss designer.

3. A project-specific permanent individual truss member restraint/bracing design shall be permitted to be specified by any registered design professional.

24.3.4.1.3 Trusses spanning 60 feet or greater.

The owner or the owner’s authorized agent shall contract with any qualified registered design professional for the design of the temporary installation restraint/bracing and the permanent individual truss member restraint/bracing for all trusses with clear spans 18 288 mm (60 feet) or greater.
24.3.4.1.4 Truss designer.
The individual or organization responsible for the design of trusses.

24.3.4.1.4.1 Truss design drawings.
Where required by the registered design professional, the Head of Works department or the statutes of the jurisdiction in which the project is to be constructed, each individual truss design drawing shall bear the seal and signature of the truss designer.

Exceptions:
1. Where a cover sheet and truss index sheet are combined into a single sheet and attached to the set of truss design drawings, the single cover/truss index sheet is the only document required to be signed and sealed by the truss designer.

2. Where a cover sheet and a truss index sheet are separately provided and attached to the set of truss design drawings, the cover sheet and the truss index sheet are the only documents required to be signed and sealed by the truss designer.

24.3.4.2 Truss placement diagram.
The truss manufacturer shall provide a truss placement diagram that identifies the proposed location for each individually designated truss and references the corresponding truss design drawing. The truss placement diagram shall be provided as part of the truss Submission package, and with the shipment of trusses delivered to the job site. Truss placement diagrams that serve only as a guide for installation and do not deviate from the permit Submission drawings shall not be required to bear the seal or signature of the truss designer.

24.3.4.3 Truss Submission package.
The truss Submission package provided by the truss manufacturer shall consist of each individual truss design drawing, the truss placement diagram, the permanent individual truss member restraint/bracing method and details and any other structural details germane to the trusses; and, as applicable, the cover/truss index sheet.

24.3.4.4 Anchorage.
The design for the transfer of loads and anchorage of each truss to the supporting structure is the responsibility of the registered design professional.

24.3.4.5 Alterations to trusses.
Truss members and components shall not be cut, notched, drilled, spliced or otherwise altered in any way without written concurrence and approval of a registered design professional. Alterations resulting in the addition of loads to any member (for example, HVAC equipment, piping, additional roofing or insulation) shall not be permitted without verification that the truss is capable of supporting such additional loading.

24.3.4.6 GS A 573/ A 573 M specifications.
In addition to Clauses 24.3.4.1 through 24.3.4.5, the design, manufacture and quality assurance of metal-plate-connected wood trusses shall be in accordance with GS A 573/ A 573 M. Job-site inspections shall be in compliance with this Code, as applicable.

24.3.4.7 Truss quality assurance.
Trusses not part of a manufacturing process in accordance with either Clause 24.3.4.6 or a referenced standard, which provides requirements for quality control done under the supervision of a third-party quality control agency, shall be manufactured in compliance with Clauses 19.4.2.5 and 19.5.5, as applicable.

24.3.5 Test standard for joist hangers.
Joist hangers shall be in accordance with ASTM D7147.

24.3.6 Nails and staples.
Nails and staples shall conform to requirements of ASTM F1667, including Supplement 1. Nails
used for framing and sheathing connections shall have minimum average bending yield strengths as follows: 551 MPa (80 kips per square inch (ksi)) for shank diameters larger than 4.50 mm (0.177 inch) but not larger than 6.45 mm (0.254 inch), 620 MPa (90 ksi) for shank diameters larger than 3.61 mm (0.142 inch) but not larger than 4.50 mm (0.177 inch) and 689 MPa (100 ksi) for shank diameters of not less than 2.51 mm (0.099 inch) but not larger than 3.61 mm (0.142 inch). Staples used for framing and sheathing connections shall have minimum average bending moments as follows: 0.41 N·m (3.6 in.-lbs) for No. 16 gage staples, 4.0 in.-lbs (0.45 N·m) for No. 15 gage staples, and 4.3 in.-lbs (0.49 N·m) for No. 14 gage staples.

24.3.7 Shrinkage.
Consideration shall be given in design to the possible effect of cross-grain dimensional changes considered vertically that may occur in timber fabricated in a green condition.

24.4 GENERAL CONSTRUCTION REQUIREMENTS

24.4.1 General.
The provisions of this clause apply to design methods specified in Clause 24.2.1.

24.4.2 Size of structural members.
Computations to determine the required sizes of members shall be based on the net dimensions (actual sizes) and not nominal sizes.

24.4.3 Wall framing.
The framing of exterior and interior walls shall be in accordance with the provisions specified in Clause 24.8 unless a specific design is furnished.

24.4.3.1 Bottom plates.
Studs shall have full bearing on a 2-inch-thick (actual 1 \( \frac{1}{2} \) -inch, 38 mm) or larger plate or sill having a width not less than equal to the width of the studs.

24.4.3.2 Framing over openings.
Headers, double joists, trusses or other approved assemblies that are of adequate size to transfer loads to the vertical members shall be provided over window and door openings in load-bearing walls and partitions.

24.4.3.3 Shrinkage.
Wood walls and bearing partitions shall not support more than two floors and a roof unless an analysis satisfactory to the Head of Works department shows that shrinkage of the wood framing will not have adverse effects on the structure or any plumbing, electrical or mechanical systems or other equipment installed therein due to excessive shrinkage or differential movements caused by shrinkage. The analysis shall show that the roof drainage system and the foregoing systems or equipment will not be adversely affected or, as an alternate, such systems shall be designed to accommodate the differential shrinkage or movements.

24.4.4 Floor and roof framing.
The framing of wood-joisted floors and wood-framed roofs shall be in accordance with the provisions specified in Clause 24.8 unless a specific design is furnished.

24.4.5 Framing around flues and chimneys.
Combustible framing shall be not less than 51 mm (2 inches), but shall be not less than the distance specified in Clauses 22.11 and 22.13 from flues, chimneys and fireplaces, and 152 mm (6 inches) away from flue openings.

24.4.6 Exterior wall sheathing.
Wall sheathing on the outside of exterior walls, including gables, and the connection of the sheathing to framing shall be designed in accordance with the general provisions of this Code and shall be capable of resisting wind pressures in accordance with this code.
24.4.6.1 Wood structural panel sheathing.

Where wood structural panel sheathing is used as the exposed finish on the outside of exterior walls, it shall have an exterior exposure durability classification. Where wood structural panel sheathing is used elsewhere, but not as the exposed finish, it shall be of a type manufactured with exterior glue (Exposure 1 or Exterior). Wood structural panel sheathing, connections and framing spacing shall be in accordance with Table 24.4.6.1 for the applicable wind speed and exposure category where used in enclosed buildings with a mean roof height not greater than 9144 mm (30 feet) and a topographic factor (K_{z,t}) of 1.0.

### TABLE 24.4.6.1 MAXIMUM ALLOWABLE STRESS DESIGN WIND SPEED, V_{asd} PERMITTED FOR WOOD STRUCTURAL PANEL WALL SHEATHING USED TO RESIST WIND PRESSURES

<table>
<thead>
<tr>
<th>MINIMUM NAIL PENETRATION (INCHES)</th>
<th>MINIMUM WOOD STRUCTURAL PANEL SPAN RATING</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (INCHES)</th>
<th>MAXIMUM WALL STUD SPACING (INCHES)</th>
<th>PANEL NAIL SPACING</th>
<th>MAXIMUM ALLOWABLE STRESS DESIGN WIND SPEED, V_{asd} (MPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6d common (2.0&quot; x 0.113&quot;)</td>
<td>1.5</td>
<td>24/0, 3/8</td>
<td>16</td>
<td>6, 12</td>
<td>110, 90, 85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24/16, 7/16</td>
<td>16</td>
<td>6, 12</td>
<td>110, 100, 90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150, 125, 110</td>
</tr>
<tr>
<td>8d common (2.5&quot; x 0.131&quot;)</td>
<td>1.75</td>
<td>24/16, 7/16</td>
<td>16</td>
<td>6, 12</td>
<td>130, 110, 105</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150, 125, 110</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>110, 90, 85</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 mile per hour = 0.447 m/s.

a. Panel strength axis shall be parallel or perpendicular to supports. Three-ply plywood sheathing with studs spaced more than 16 inches on center shall be applied with panel strength axis perpendicular to supports.

b. The table is based on wind pressures acting toward and away from building surfaces in accordance with Clause 30.7 of ASCE 7. Lateral requirements shall be in accordance with Clause 24.5 or 24.8.

c. Wood structural panels with span ratings of wall-16 or wall-24 shall be permitted as an alternative to panels with a 24/0 span rating. Plywood siding rated 16 on center or 24 on center shall be permitted as an alternative to panels with a 24/16 span rating. Wall-16 and plywood siding 16 on center shall be used with studs spaced not more than 16 inches on center.

d. V_{asd} shall be determined in accordance with this Code.

746
24.4.7 Interior paneling.

Softwood wood structural panels used for interior paneling shall conform to the provisions of Part 8 and shall be installed in accordance with Table 24.4.10.1. Panels shall comply with GS EN 312. Prefinished hardboard paneling shall meet the requirements of GS 1029. Hardwood plywood shall conform to GS 198.

24.4.8 Floor and roof sheathing.

Structural floor sheathing and structural roof sheathing shall comply with Clauses 24.4.8.1 and 24.4.8.2, respectively.

---

**TABLE 24.4.8(1) ALLOWABLE SPANS FOR TIMBER FLOOR AND ROOF SHEATHING**

<table>
<thead>
<tr>
<th>SPAN (inches)</th>
<th>Minimum Net Thickness (inches) of Timber Placed</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perpendicular to supports</td>
<td>Diagonally to supports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surfed dry</td>
<td>Surfed unseasoned</td>
<td>Surfed dry</td>
</tr>
<tr>
<td>Floors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>3/4</td>
<td>25/32</td>
<td>3/4</td>
</tr>
<tr>
<td>16</td>
<td>5/8</td>
<td>11/16</td>
<td>5/8</td>
</tr>
<tr>
<td>Roofs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>5/8</td>
<td>11/16</td>
<td>3/4</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. Maximum 19-percent moisture content.

---

**TABLE 24.4.8(2) SHEATHING TIMBER, MINIMUM GRADE REQUIREMENTS: BOARD GRADE**

<table>
<thead>
<tr>
<th>SOLID FLOOR OR ROOF SHEATHING</th>
<th>SPACED ROOF SHEATHING</th>
<th>GRADING RULES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>Standard</td>
<td>GS 198</td>
</tr>
<tr>
<td>common or utility</td>
<td>common or standard</td>
<td></td>
</tr>
</tbody>
</table>

---

**TABLE 24.4.8(3) ALLOWABLE SPANS AND LOADS FOR WOOD STRUCTURAL PANEL SHEATHING AND SINGLE-FLOOR GRADES CONTINUOUS OVER TWO OR MORE SPANS WITH STRENGTH AXIS PERPENDICULAR TO SUPPORTS**

<table>
<thead>
<tr>
<th>SHEATHING GRADERS</th>
<th>ROOFb</th>
<th>FLOORc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel span rating roof/ floor span</td>
<td>Maximum span (inches)</td>
<td>Load (psf)</td>
</tr>
<tr>
<td></td>
<td>With edge support</td>
<td>Without edge support</td>
</tr>
<tr>
<td>16/0</td>
<td>3/8</td>
<td>16</td>
</tr>
<tr>
<td>20/0</td>
<td>3/8</td>
<td>20</td>
</tr>
<tr>
<td>24/0</td>
<td>3/8 7/16' 1/2</td>
<td>24</td>
</tr>
</tbody>
</table>
### SINGLE FLOOR GRADES

<table>
<thead>
<tr>
<th>Panel span rating</th>
<th>Panel thickness (inches)</th>
<th>Maximum span (inches)</th>
<th>Load (psf)</th>
<th>Maximum span (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With edge support</td>
<td>Without edge support</td>
<td>Total load</td>
</tr>
<tr>
<td>24/16</td>
<td>7/16, 1/2</td>
<td>24</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>32/16</td>
<td>15/32, 1/8</td>
<td>32</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>40/20</td>
<td>19/32, 5/8</td>
<td>40</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>48/24</td>
<td>23/32, 3/8</td>
<td>48</td>
<td>36</td>
<td>45</td>
</tr>
<tr>
<td>54/32</td>
<td>7/8, 1</td>
<td>54</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>60/32</td>
<td>7/8, 1</td>
<td>60</td>
<td>48</td>
<td>45</td>
</tr>
</tbody>
</table>

#### ROOF

<table>
<thead>
<tr>
<th>Panel span rating</th>
<th>Panel thickness (inches)</th>
<th>Maximum span (inches)</th>
<th>Load (psf)</th>
<th>Maximum span (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With edge support</td>
<td>Without edge support</td>
<td>Total load</td>
</tr>
<tr>
<td>16 o.c.</td>
<td>1/2, 1/2, 3/2</td>
<td>24</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>20 o.c.</td>
<td>19/32, 5/8</td>
<td>32</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>24 o.c.</td>
<td>23/32, 3/4</td>
<td>48</td>
<td>36</td>
<td>35</td>
</tr>
<tr>
<td>32 o.c.</td>
<td>7/8, 1</td>
<td>48</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>48 o.c.</td>
<td>13/32, 1/8</td>
<td>60</td>
<td>48</td>
<td>50</td>
</tr>
</tbody>
</table>

#### FLOOR

<table>
<thead>
<tr>
<th>Panel span rating</th>
<th>Panel thickness (inches)</th>
<th>Maximum span (inches)</th>
<th>Load (psf)</th>
<th>Maximum span (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With edge support</td>
<td>Without edge support</td>
<td>Total load</td>
</tr>
<tr>
<td>16 o.c.</td>
<td>1/2, 1/2, 3/2</td>
<td>24</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>20 o.c.</td>
<td>19/32, 5/8</td>
<td>32</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>24 o.c.</td>
<td>23/32, 3/4</td>
<td>48</td>
<td>36</td>
<td>35</td>
</tr>
<tr>
<td>32 o.c.</td>
<td>7/8, 1</td>
<td>48</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>48 o.c.</td>
<td>13/32, 1/8</td>
<td>60</td>
<td>48</td>
<td>50</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kN/m².

a. Applies to panels 24 inches or wider.

b. Uniform load deflection limitations $\frac{1}{180}$ of span under live load plus dead load, $\frac{1}{240}$ under live load only.
c. Panel edges shall have approved tongue-and-groove joints or shall be supported with blocking unless \( \frac{1}{4} \) -inch minimum thickness underlayment or \( \frac{1}{2} \) inches of approved cellular or lightweight concrete is placed over the subfloor, or finish floor is \( \frac{3}{4} \) -inch wood strip. Allowable uniform load based on deflection of \( \frac{1}{360} \) of span is 100 pounds per square foot except the span rating of 48 inches on center is based on a total load of 65 pounds per square foot.

d. Allowable load at maximum span.

e. Tongue-and-groove edges, panel edge clips (one midway between each support, except two equally spaced between supports 48 inches on center), timber blocking or other. Only timber blocking shall satisfy blocked diaphragm requirements.

f. For \( \frac{1}{2} \) -inch panel, maximum span shall be 24 inches.

g. Span is permitted to be 24 inches on center where \( \frac{3}{4} \) -inch wood strip flooring is installed at right angles to joist.

h. Span is permitted to be 24 inches on center for floors where \( \frac{3}{4} \) inches of cellular or lightweight concrete is applied over the panels.

Note: For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kN/m

<table>
<thead>
<tr>
<th>IDENTIFICATION</th>
<th>MAXIMUM SPACING OF JOISTS (inches)</th>
<th>LOAD AT MAXIMUM SPAN (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species group b</td>
<td>Thickness (inches)</td>
<td>16</td>
</tr>
<tr>
<td>1</td>
<td>( \frac{1}{2} )</td>
<td>5</td>
</tr>
<tr>
<td>2, 3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Single floor span rating c</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>o.c.</td>
<td>o.c.</td>
<td>o.c.</td>
</tr>
</tbody>
</table>

TABLE 24.4.8(5) ALLOWABLE LOAD (PSF) FOR WOOD STRUCTURAL PANEL ROOF SHEATHING CONTINUOUS OVER TWO OR MORE SPANS AND STRENGTH AXIS PARALLEL TO SUPPORTS

(Plywood structural panels are five-ply, five-layer unless otherwise noted)

<table>
<thead>
<tr>
<th>PANEL GRADE</th>
<th>THICKNESS (inch)</th>
<th>MAXIMUM SPAN (inches)</th>
<th>LOAD AT MAXIMUM SPAN (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Live</td>
</tr>
<tr>
<td>Structural I sheathing</td>
<td>( \frac{7}{16} )</td>
<td>24</td>
<td>20</td>
</tr>
</tbody>
</table>
### 24.4.8.1 Structural floor sheathing.

Structural floor sheathing shall be designed in accordance with the general provisions of this Code. Floor sheathing conforming to the provisions of Table 24.4.8(1), 24.4.8(2), 24.4.8(3) or 24.4.8(4) shall be deemed to meet the requirements of this clause.

<table>
<thead>
<tr>
<th>Sheathing, other grades covered in GS 198</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/32</td>
</tr>
<tr>
<td>1/2</td>
</tr>
<tr>
<td>19/32</td>
</tr>
<tr>
<td>23/32</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kN/m\(^2\).

a. Uniform load deflection limitations \(\frac{1}{180}\) of span under live load plus dead load, \(\frac{1}{240}\) under live load only. Edges shall be blocked with timber or other approved type of edge supports.

b. For composite and four-ply plywood structural panel, load shall be reduced by 15 pounds per square foot.

### 24.4.8.2 Structural roof sheathing.

Structural roof sheathing shall be designed in accordance with the general provisions of this Code and the special provisions in this clause.

### 24.4.9 Timber decking.

Timber decking shall be designed and installed in accordance with the general provisions of this Code and Clauses 24.4.9.1 through 24.4.9.5.3.

#### 24.4.9.1 General.

Each piece of timber decking shall be square-end trimmed. Where random lengths are furnished, each piece shall be square end trimmed across the face so that not less than 90 percent of the pieces are within 0.5 degrees (0.00873 rad) of square. The ends of the pieces shall be permitted to be beveled up to 2 degrees (0.0349 rad) from the vertical with the exposed face of the piece slightly longer than the opposite face of the piece. Tongue-and-groove decking shall be installed with the tongues up on sloped or pitched roofs with pattern faces down.
24.4.9.2 Layup patterns.

Timber decking is permitted to be laid up following one of five standard patterns as defined in Clauses 2304.9.2.1 through 2304.9.2.5. Other patterns are permitted to be used provided that they are substantiated through engineering analysis.

24.4.9.2.1 Simple span pattern.

All pieces shall be supported on their ends (in other words, by two supports).

24.4.9.2.2 Two-span continuous pattern.

All pieces shall be supported by three supports, and all end joints shall occur in line on alternating supports. Supporting members shall be designed to accommodate the load redistribution caused by this pattern.

24.4.9.2.3 Combination simple and two-span continuous pattern.

Courses in end spans shall be alternating simple-span pattern and two-span continuous pattern. End joints shall be staggered in adjacent courses and shall bear on supports.

24.4.9.2.4 Cantilevered pieces intermixed pattern.

The decking shall extend across not fewer than three spans. Pieces in each starter course and every third course shall be simple span pattern. Pieces in other courses shall be cantilevered over the supports with end joints at alternating quarter or third points of the spans. Each piece shall bear on one support or more.

24.4.9.2.5 Controlled random pattern.

The decking shall extend across not fewer than three spans. End joints of pieces within 152 mm (6 inches) of the end joints of the adjacent pieces in either direction shall be separated by not fewer than two intervening courses. In the end bays, each piece shall bear on one support or more. Where an end joint occurs in an end bay, the next piece in the same course shall continue over the first inner support for not less than 610 mm (24 inches). The details of the controlled random pattern shall be as specified for each decking material in Clause 24.4.9.3.3, 24.4.9.4.3 or 24.4.9.5.3.

Decking that cantilevers beyond a support for a horizontal distance greater than 457 mm (18 inches), 610 mm (24 inches) or 914 mm (36 inches) for 51 mm (2-inch), 76 mm (3-inch) and 102 mm (4-inch) nominal thickness decking, respectively, shall comply with the following:

1. The maximum cantilevered length shall be 30 percent of the length of the first adjacent interior span.

2. A structural fascia shall be fastened to each decking piece to maintain a continuous, straight line.

3. End joints shall not be in the decking between the cantilevered end of the decking and the centerline of the first adjacent interior span.

24.4.9.3 Mechanically laminated decking.

Mechanically laminated decking shall comply with Clauses 24.4.9.3.1 through 24.4.9.3.3.

24.4.9.3.1 General.

Mechanically laminated decking consists of square-edged dimension timber laminations set on edge and nailed to the adjacent pieces and to the supports.

24.4.9.3.2 Nailing.

The length of nails connecting laminations shall be not less than two and one-half times the net thickness of each lamination. Where decking supports are 1219 mm (48 inches) on center or less, side nails shall be installed not more than 762 mm (30 inches) on center alternating between top and bottom edges, and staggered one-third of the spacing in adjacent laminations. Where supports are spaced more than 1219 mm (48 inches) on center, side nails shall be installed not more than 457 mm (18 inches) on center alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. For mechanically laminated decking constructed with laminations of 51 mm (2-inch) nominal thickness, nailing in
accordance with Table 24.4.9.3.2 shall be permitted. Two side nails shall be installed at each end of butt-jointed pieces.

Laminations shall be toenailed to supports with 20d or larger common nails. Where the supports are 1219 mm (48 inches) on center or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 1219 mm (48 inches) on center, alternate laminations shall be toenailed to every support. For mechanically laminated decking constructed with laminations of 51 mm (2-inch) nominal thickness, toenailing in accordance with Table 24.4.9.3.2 shall be permitted.

### TABLE 24.4.9.3.2 FASTENING SCHEDULE FOR MECHANICALLY LAMINATED DECKING USING LAMINATIONS OF 2-INCH NOMINAL THICKNESS

<table>
<thead>
<tr>
<th>MINIMUM NAIL SIZE (Length x Diameter) (inches)</th>
<th>MAXIMUM SPACING BETWEEN FACE NAILS (inches)</th>
<th>NUMBER OF TOENAILS INTO SUPPORTS C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decking Supports &lt; 48 inches o.c.</td>
<td>Decking Supports &gt; 48 inches o.c.</td>
<td></td>
</tr>
<tr>
<td>4 × 0.192</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>4 × 0.162</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>4 × 0.148</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>31/2 × 0.162</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>31/2 × 0.148</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>31/2 × 0.135</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>3 × 0.148</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>3 × 0.128</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>23/4 × 0.148</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>23/4 × 0.131</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>23/4 × 0.120</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm

a. Nails shall be driven perpendicular to the lamination face, alternating between top and bottom edges.

b. Where nails penetrate through two laminations and into the third, they shall be staggered one-third of the spacing in adjacent laminations. Otherwise, nails shall be staggered one-half of the spacing in adjacent laminations.

c. Where supports are 48 inches on center or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches on center, alternate laminations shall be toenailed to every support.

### 24.4.9.3.3 Controlled random pattern.

There shall be a minimum distance of 610 mm (24 inches) between end joints in adjacent courses. The pieces in the first and second courses shall bear on not fewer than two supports with end joints in these two courses occurring on alternate supports. Not more than seven intervening courses shall be permitted before this pattern is repeated.

### 24.4.9.4 Fifty millimeter sawn tongue-and-groove decking.

50 mm (2 inches) sawn tongue-and-groove decking shall comply with Clauses 24.4.9.4.1 through 24.4.9.4.3.

#### 24.4.9.4.1 General.

51 mm (two-inch) decking shall have a maximum moisture content of 15 percent. Decking shall be machined with a single tongue-and-groove pattern. Each decking piece shall be nailed to each support.

#### 24.4.9.4.2 Nailing.

Each piece of decking shall be toenailed at each support with one 16d common nail through the tongue and face-nailed with one 16d common nail.

#### 24.4.9.4.3 Controlled random pattern.

There shall be a minimum distance of 610 mm (24 inches) between end joints in adjacent courses. The pieces in the first and second courses shall bear on not fewer than two supports with end joints in these two courses occurring on alternate supports. Not more than seven intervening courses shall be permitted before this pattern is repeated.
24.4.9.5 Seventy-five and one hundred sawn tongue-and-groove decking.

75 mm and 100 mm (Three- and four-inch) sawn tongue-and-groove decking shall comply with Clauses 24.4.9.5.1 through 24.4.9.5.3.

24.4.9.5.1 General.

76 mm (Three-inch) and 102 mm (four-inch) decking shall have a maximum moisture content of 19 percent. Decking shall be machined with a double tongue-and-groove pattern. Decking pieces shall be interconnected and nailed to the supports.

24.4.9.5.2 Nailing.

Each piece shall be toenailed at each support with one 40d common nail and face-nailed with one 60d common nail. Courses shall be spiked to each other with 203 mm (8-inch) spikes at maximum intervals of 762 mm (30 inches) through predrilled edge holes penetrating to a depth of approximately 102 mm (4 inches). One spike shall be installed at a distance not exceeding 254 mm (10 inches) from the end of each piece.

24.4.9.5.3 Controlled random pattern.

There shall be a minimum distance of 1219 mm (48 inches) between end joints in adjacent courses. Pieces not bearing on a support are permitted to be located in interior bays provided that the adjacent pieces in the same course continue over the support for not less than 610 mm (24 inches). This condition shall not occur more than once in every six courses in each interior bay.

24.4.10 Connectors and fasteners.

Connectors and fasteners shall comply with the applicable provisions of Clauses 24.4.10.1 through 24.4.10.7.

24.4.10.1 Fastener requirements.

Connections for wood members shall be designed in accordance with the appropriate methodology in Clause 24.2.1. The number and size of fasteners connecting wood members shall be not less than that set forth in Table 24.4.10.1.

### TABLE 24.4.10.1

<p>| FASTENING SCHEDULE |</p>
<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Blocking between ceiling joists, rafters or trusses</td>
<td>3-8d common (2(\ell_i^m) x 0.131&quot;) or 3-10d box (3&quot; x 0.128&quot;) or 3-3&quot; x 0.131&quot; nails; or 3-3&quot; 14 gage staples, (1_t^m)&quot; crown</td>
<td>Each end, toenail</td>
</tr>
<tr>
<td>to top plate or other framing below</td>
<td>2-8d common (2(\ell_i^m) x 0.131&quot;) 2-3&quot; x 0.131&quot; nails 2-3&quot; 14 gage staples</td>
<td>Each end, toenail</td>
</tr>
<tr>
<td></td>
<td>2-16d common (3(\ell_i^m) x 0.162&quot;) 3-3&quot; x 0.131&quot; nails 3-3&quot; 14 gage staples</td>
<td>End nail</td>
</tr>
<tr>
<td>Blocking between rafters or truss not at the wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>top plate, to rafter or truss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat blocking to truss and web filler</td>
<td>16d common (3(\ell_i^m) x 0.162&quot;) @ 6&quot; o.c. 3&quot; x 0.131&quot; nails @ 6&quot; o.c. 3&quot; x 14 gage staples @ 6&quot; o.c</td>
<td>Face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Ceiling joists to top plate</td>
<td>3-8d common (2(\ell_i^m) x 0.131&quot;) or 3-10d box (3&quot; x 0.128&quot;) or 3-3&quot; x 0.131&quot; nails; or 3-3&quot; 14 gage staples, (1_t^m)&quot; crown</td>
<td>Each joist, toenail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ceiling joist not attached to parallel rafter, laps</td>
<td>3-16d common (3(\ell_i^m) x 0.162&quot;) or 4-10d box (3&quot; x 0.128&quot;) or 4-3&quot; x 0.131&quot; nails; or 4-3&quot; 14 gage staples, (1_t^m)&quot; crown</td>
<td>Face nail</td>
</tr>
<tr>
<td>over partitions (no thrust)</td>
<td>(see Section 2308.7.3.1, Table 2308.7.3.1)</td>
<td></td>
</tr>
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<td></td>
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<tr>
<td>4. Ceiling joist attached to parallel rafter (heal joint)</td>
<td>Per Table 2308.7.3.1</td>
<td>Face nail</td>
</tr>
<tr>
<td>(see Section 2308.7.3.1, Table 2308.7.3.1)</td>
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<td></td>
</tr>
<tr>
<td>5. Collar tie to rafter</td>
<td>3-10d common (3&quot; x 0.148&quot;) or 4-10d box (3&quot; x 0.128&quot;) or 4-3&quot; x 0.131&quot; nails; or 4-3&quot; 14 gage staples, (1_t^m)&quot; crown</td>
<td>Face nail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Rafter or roof truss to top plate</td>
<td>3-10d common (3&quot; x 0.148&quot;) or 3-16d box (3(\ell_i^m) x 0.135&quot;) or 4-10d box (3&quot; x 0.128&quot;) or 4-3&quot; x 0.131&quot; nails; or 4-3&quot; 14 gage staples, (1_t^m)&quot; crown</td>
<td>Toenail^2</td>
</tr>
<tr>
<td>(See Section 2308.7.5, Table 2308.7.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Roof rafters to ridge valley or hip rafters; or roof</td>
<td>2-16d common (3(\ell_i^m) x 0.162&quot;) or 3-10d box (3&quot; x 0.128&quot;) or 3-3&quot; x 0.131&quot; nails; or 3-3&quot; 14 gage staples, (1_t^m)&quot; crown; or 3-10d common (3&quot; x 0.148&quot;) or 4-16d box (3(\ell_i^m) x 0.135&quot;) or 4-10d box (3&quot; x 0.128&quot;) or 4-3&quot; x 0.131&quot; nails; or 4-3&quot; 14 gage staples, (1_t^m)&quot; crown</td>
<td>End nail</td>
</tr>
<tr>
<td>rafter to 2-inch ridge beam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
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(Continued)
TABLE 24.4.10.1—continued  
FASTENING SCHEDULE

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Stud to stud (not at braced wall panels)</td>
<td>16d common (3½&quot; x 0.162&quot;); 10d box (3&quot; x 0.128&quot;); 3&quot; x 0.131&quot; nails; 3-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>24&quot; o.c. face nail 16&quot; o.c. face nail</td>
</tr>
<tr>
<td>9. Stud to stud and abutting studs at intersecting wall corners (at braced wall panels)</td>
<td>16d common (3½&quot; x 0.162&quot;); 16d box (3½&quot;, 0.135&quot;); 3&quot; x 0.131&quot; nails; 3-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>16&quot; o.c. face nail 12&quot; o.c. face nail</td>
</tr>
<tr>
<td>10. Built-up header (2&quot; to 2&quot; header)</td>
<td>16d common (3½&quot; x 0.162&quot;); 16d box (3½&quot;, 0.135&quot;)</td>
<td>16&quot; o.c. each edge, face nail</td>
</tr>
<tr>
<td>11. Continuous header to stud</td>
<td>4-8d common (2½&quot; x 0.131&quot;); 4-10d box (3&quot; x 0.128&quot;)</td>
<td>Toenail</td>
</tr>
<tr>
<td>12. Top plate to top plate</td>
<td>10d box (3&quot; x 0.128&quot;); 3&quot; x 0.131&quot; nails; 3-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>16&quot; o.c. face nail 12&quot; o.c. face nail</td>
</tr>
<tr>
<td>13. Top plate to top plate, at end joints</td>
<td>8-16d common (3½&quot; x 0.162&quot;); 12-10d box (3&quot; x 0.128&quot;); 12-3&quot; x 0.131&quot; nails; 12-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>Each side of end joint, face nail (minimum 24&quot; lap splice length each side of end joint)</td>
</tr>
<tr>
<td>14. Bottom plate to joist, rim joist, band joist or blocking (not at braced wall panels)</td>
<td>16d common (3½&quot; x 0.162&quot;); 16d box (3½&quot;, 0.135&quot;); 3&quot; x 0.131&quot; nails; 3-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>16&quot; o.c. face nail 12&quot; o.c. face nail</td>
</tr>
<tr>
<td>15. Bottom plate to joist, rim joist, band joist or blocking at braced wall panels</td>
<td>2-16d common (3½&quot; x 0.162&quot;); 3-16d box (3½&quot;, 0.135&quot;); 4-3&quot; x 0.131&quot; nails; 4-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>16&quot; o.c. face nail Toenail</td>
</tr>
<tr>
<td>16. Stud to top or bottom plate</td>
<td>4-8d common (2½&quot; x 0.131&quot;); 4-10d box (3&quot; x 0.128&quot;); 4-3&quot; x 0.131&quot; nails; 4-3&quot; 14 gage staples, 7/16&quot; crown;</td>
<td>Toenail</td>
</tr>
<tr>
<td>17. Top plates, laps at corners and intersections</td>
<td>2-16d common (3½&quot; x 0.162&quot;); 3-10d box (3&quot; x 0.128&quot;); 3-3&quot; x 0.131&quot; nails; 3-3&quot; 14 gage staples, 7/16&quot; crown</td>
<td>16&quot; o.c. face nail 12&quot; o.c. face nail</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 24.4.10.1—continued

**FASTENING SCHEDULE**

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. 1&quot; brace to each stud and plate</td>
<td>2-8d common (2½&quot; × 0.131&quot;) or 2-10d box (3&quot; × 0.128&quot;); 2-3&quot; × 0.131&quot; nails; 2-3&quot; 14 gage staples, γw, crown</td>
<td>Face nail</td>
</tr>
<tr>
<td>19. 1&quot; × 6&quot; sheathing to each bearing</td>
<td>2-8d common (2½&quot; × 0.131&quot;) or 2-10d box (3&quot; × 0.128&quot;)</td>
<td>Face nail</td>
</tr>
<tr>
<td>20. 1&quot; × 8&quot; and wider sheathing to each bearing</td>
<td>3-8d common (2½&quot; × 0.131&quot;) or 2-10d box (3&quot; × 0.128&quot;)</td>
<td>Face nail</td>
</tr>
<tr>
<td><strong>Floor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Joist to sill, top plate, or girder</td>
<td>3-8d common (2½&quot; × 0.131&quot;) or floor 2-10d box (3&quot; × 0.128&quot;); 3-3&quot; × 0.131&quot; nails; 3-3&quot; 14 gage staples, γw, crown</td>
<td>Toenail</td>
</tr>
<tr>
<td>22. Rim joist, band joist, or blocking to top plate, sill or other framing below</td>
<td>6d common (2½&quot; × 0.131&quot;) or 10d box (3&quot; × 0.128&quot;); 3&quot; × 0.131&quot; nails; 2&quot; 14 gage staples, γw, crown</td>
<td>6&quot; o.c., toenail</td>
</tr>
<tr>
<td>23. 1&quot; × 6&quot; subfloor or less to each joist</td>
<td>2-8d common (2½&quot; × 0.131&quot;) or 2-10d box (3&quot; × 0.128&quot;)</td>
<td>Face nail</td>
</tr>
<tr>
<td>24. 2&quot; subfloor to joist or girder</td>
<td>2-16d common (3½&quot; × 0.162&quot;)</td>
<td>Face nail</td>
</tr>
<tr>
<td>25. 2&quot; planks (plank &amp; beam – floor &amp; roof)</td>
<td>2-16d common (3½&quot; × 0.162&quot;)</td>
<td>Each bearing, face nail</td>
</tr>
</tbody>
</table>
| 26. Built-up girders and beams, 2" lumber layers | 20d common (4" × 0.192") or 10d box (3" × 0.128"); 3" × 0.131" nails; 3" 14 gage staples, γw, crown | 32" o.c., face nail at top and bottom staggered on opposite sides

*And:

| 2-20d common (4" × 0.192"); 3-30d box (3" × 0.128"); 3-3" × 0.131" nails; 3-3" 14 gage staples, γw, crown | Ends and at each splice, face nail |
| 27. Ledger strip supporting joists or rafters | 3-16d common (3½" × 0.162") or 4-10d box (3" × 0.128"); 4-3" × 0.131" nails; 4-3" 14 gage staples, γw, crown | Each joist or rafter, face nail |
| 28. Joist to hand joist or rim joist | 2-16d common (3½" × 0.162") or 4-10d box (3" × 0.128"); 4-3" × 0.131" nails; 4-3" 14 gage staples, γw, crown | End nail |
| 29. Bridging or blocking to joist, rafter or truss | 2-8d common (2½" × 0.131") or 2-10d box (3" × 0.128"); 2-3" × 0.131" nails; 2-3" 14 gage staples, γw, crown | Each end, toenail |

(Continued)
### TABLE 24.4.10.1—continued

**FASTENING SCHEDULE**

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood structural panels (WSP), subfloor, roof and interior wall sheathing to framing and particleboard wall sheathing to framing*</td>
<td>Edges (inches)</td>
<td>Intermediate supports (inches)</td>
</tr>
<tr>
<td>30. $\frac{3}{4}&quot; - 1&quot;$</td>
<td>6d common or deformed (2&quot; × 0.113&quot;) (subfloor and wall)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>8d common or deformed (2/4&quot; × 0.131&quot;) (roof) or RSRS-01 (2/4&quot; × 0.133&quot;) nail (roof)*</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$2\frac{1}{4}&quot;$ × 0.113&quot; nail (subfloor and wall)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$\frac{3}{4}&quot;$ 16 gage staple, $\frac{7}{64}&quot;$ crown (subfloor and wall)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>$2\frac{1}{4}&quot;$ × 0.113&quot; nail (roof)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>$\frac{3}{4}&quot;$ 16 gage staple, $\frac{7}{64}&quot;$ crown (roof)</td>
<td>3</td>
</tr>
<tr>
<td>31. $\frac{1}{2}&quot; - \frac{3}{4}&quot;$</td>
<td>8d common (2&quot; × 0.131&quot;); or 6d deformed (2&quot; × 0.113&quot;) (subfloor and wall)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>8d common or deformed (2/4&quot; × 0.131&quot;) (roof) or RSRS-01 (2/4&quot; × 0.133&quot;) nail (roof)*</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$2\frac{1}{4}&quot;$ × 0.113&quot; nail; or $2&quot;$ 16 gage staple, $\frac{7}{64}&quot;$ crown</td>
<td>4</td>
</tr>
<tr>
<td>32. $\frac{1}{4}&quot; - 1&quot;$</td>
<td>10d common (3&quot; × 0.148&quot;); or 8d deformed (2/4&quot; × 0.131&quot;)</td>
<td>6</td>
</tr>
<tr>
<td><strong>Other exterior wall sheathing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. $\frac{1}{4}&quot;$ fiberboard sheathingb</td>
<td>$\frac{1}{8}&quot;$ galvanized roofing nail (1/8&quot; head diameter); or $\frac{3}{4}&quot;$ 16 gage staple with $\frac{7}{64}&quot;$ or 1&quot; crown</td>
<td>3</td>
</tr>
<tr>
<td>34. $\frac{3}{8}&quot;$ fiberboard sheathingb</td>
<td>$\frac{1}{8}&quot;$ galvanized roofing nail (1/8&quot; diameter head); or $\frac{3}{4}&quot;$ 16 gage staple with $\frac{7}{64}&quot;$ or 1&quot; crown</td>
<td>3</td>
</tr>
<tr>
<td><strong>Wood structural panels, combination subfloor underlayment to framing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. $\frac{1}{4}&quot;$ and less</td>
<td>8d common (2&quot; × 0.131&quot;); or 6d deformed (2&quot; × 0.113&quot;)</td>
<td>6</td>
</tr>
<tr>
<td>36. $\frac{1}{4}&quot; - 1&quot;$</td>
<td>8d common (2&quot; × 0.131&quot;); or 8d deformed (2/4&quot; × 0.131&quot;)</td>
<td>6</td>
</tr>
<tr>
<td>37. $1\frac{1}{4}&quot; - 1\frac{1}{2}&quot;$</td>
<td>10d common (3&quot; × 0.148&quot;); or 8d deformed (2/4&quot; × 0.131&quot;)</td>
<td>6</td>
</tr>
<tr>
<td><strong>Panel siding to framing</strong></td>
<td></td>
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</tr>
<tr>
<td>38. $\frac{1}{4}&quot;$ or less</td>
<td>6d corrosion-resistant siding (1/4&quot; × 0.106&quot;); or 6d corrosion-resistant casing (2&quot; × 0.099&quot;)</td>
<td>6</td>
</tr>
<tr>
<td>39. $\frac{1}{4}&quot;$</td>
<td>8d corrosion-resistant siding (2/4&quot; × 0.128&quot;); or 8d corrosion-resistant casing (2/4&quot; × 0.113&quot;)</td>
<td>6</td>
</tr>
</tbody>
</table>

(Continued)
TABLE 24.4.10.1—continued
FASTENING SCHEDULE

<table>
<thead>
<tr>
<th>DESCRIPTION OF BUILDING ELEMENTS</th>
<th>NUMBER AND TYPE OF FASTENER</th>
<th>SPACING AND LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood structural panels (WSP), subfloor, roof and interior wall sheathing to framing and particleboard wall sheathing to framing*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior paneling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40. 1/4&quot;</td>
<td>4d casing (1/2&quot; x 0.080&quot;) or 4d finish (1/2&quot; x 0.072&quot;)</td>
<td>6</td>
</tr>
<tr>
<td>41. 5/8&quot;</td>
<td>6d casing (2&quot; x 0.099&quot;) or 6d finish (Panel supports at 24 inches)</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. Nails spaced at 6 inches at intermediate supports where spans are 48 inches or more. For nailing of wood structural panel and particleboard diaphragms and shear walls, refer to Clause 24.5. Nails for wall sheathing are permitted to be common, box or casing.

b. Spacing shall be 6 inches on center on the edges and 12 inches on center at intermediate supports for nonstructural applications. Panel supports at 16 inches (20 inches if strength axis in the long direction of the panel, unless otherwise marked).

c. Where a rafter is fastened to an adjacent parallel ceiling joist in accordance with this schedule and the ceiling joist is fastened to the top plate in accordance with this schedule, the number of toenails in the rafter shall be permitted to be reduced by one nail.

d. RSRS-01 is a Roof Sheathing Ring Shank nail meeting the specifications in ASTM F1667.

24.4.10.2 Sheathing fasteners.

Sheathing nails or other approved sheathing connectors shall be driven so that their head or crown is flush with the surface of the sheathing.

24.4.10.3 Joist hangers and framing anchors.

Connections depending on joist hangers or framing anchors, ties and other mechanical fastenings not otherwise covered are permitted where approved. The vertical load-bearing capacity, torsional moment capacity and deflection characteristics of joist hangers shall be determined in accordance with ASTM D7147.

24.4.10.4 Other fasteners.

 Clips, staples, glues and other approved methods of fastening are permitted where approved.

24.4.10.5 Fasteners and connectors in contact with preservative-treated and fire-retardant-treated wood.

Fasteners, including nuts and washers, and connectors in contact with preservative-treated and fire-retardant-treated wood shall be in accordance with Clauses 24.4.10.5.1 through 24.4.10.5.4. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A153. Stainless steel driven fasteners shall be in accordance with the material requirements of ASTM F1667.

24.4.10.5.1 Fasteners and connectors for preservative-treated wood.

Fasteners, including nuts and washers, in contact with preservative-treated wood shall be of hot-dipped zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Staples shall be of stainless steel. Fasteners other than nails, staples, timber rivets, wood screws and lag screws shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B695, Class 55 minimum. Connectors that are used in exterior applications and in contact with preservative-treated wood shall have coating types and weights in accordance with the treated wood or connector manufacturer’s recommendations. In the absence of manufacturer's recommendations, not less than ASTM A653, Type G185 zinc-coated galvanized steel, or equivalent, shall be used.

Exception: Plain carbon steel fasteners, including nuts and washers, in SBX/DOT and zinc borate preservative-treated wood in an interior, dry environment shall be permitted.
2304.10.5.2 Fastenings for wood foundations.
Fastenings, including nuts and washers, for wood foundations shall be as required and approved by the Works Department.

24.4.10.5.3 Fasteners for fire-retardant-treated wood used in exterior applications or wet or damp locations.
Fastenings, including nuts and washers, for fire-retardant-treated wood used in exterior applications or wet or damp locations shall be of hot-dipped zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Staples shall be of stainless steel. Fasteners other than nails, staples, timber rivets, wood screws and lag screws shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B695, Class 55 minimum.

24.4.10.5.4 Fasteners for fire-retardant-treated wood used in interior applications.
Fastenings, including nuts and washers, for fire-retardant-treated wood used in interior locations shall be in accordance with the manufacturer’s recommendations. In the absence of manufacturer’s recommendations, Clause 24.4.10.5.3 shall apply.

24.4.10.6 Load path.
Where wall framing members are not continuous from the foundation sill to the roof, the members shall be secured to ensure a continuous load path. Where required, sheet metal clamps, ties or clips shall be formed of galvanized steel or other approved corrosion-resistant material not less than 0.836 mm (0.0329-inch) base metal thickness.

24.4.10.7 Framing requirements.
Wood columns and posts shall be framed to provide full end bearing. Alternatively, column-and-post end connections shall be designed to resist the full compressive loads, neglecting end-bearing capacity. Column-and-post end connections shall be fastened to resist lateral and net induced uplift forces.

24.4.11 Heavy timber construction.
Where a structure, portion thereof or individual structural elements are required by provisions of this Code to be of heavy timber, the building elements therein shall comply with the applicable provisions of Clauses 24.4.11.1 through 24.4.11.4. Minimum dimensions of heavy timber shall comply with the applicable requirements in Table 24.4.11 based on roofs or floors supported and the configuration of each structural element, or in Clauses 24.4.11.2 through 24.4.11.4. Timber decking shall be in accordance with Clause 24.4.9.
TABLE 24.4.11
MINIMUM DIMENSIONS OF HEAVY TIMBER STRUCTURAL MEMBERS

<table>
<thead>
<tr>
<th>SUPPORTING</th>
<th>HEAVY TIMBER STRUCTURAL ELEMENTS</th>
<th>MINIMUM NOMINAL SOLID SAWN SIZE</th>
<th>MINIMUM GLUED-LAMINATED NET SIZE</th>
<th>MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Width, inch</td>
<td>Depth, inch</td>
<td>Width, inch</td>
</tr>
<tr>
<td>Floor loads only or combined floor and roof loads</td>
<td>Columns; Framed sawn or glued-laminated timber arches that spring from the floor line; Framed timber trusses</td>
<td>8</td>
<td>8</td>
<td>6½</td>
</tr>
<tr>
<td></td>
<td>Wood beams and girders</td>
<td>6</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Roof loads only</td>
<td>Columns (roof and ceiling loads): Lower half of: wood-frame or glued-laminated arches that spring from the floor line or from grade</td>
<td>6</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Upper half of: wood-frame or glued-laminated arches that spring from the floor line or from grade</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Framed timber trusses and other roof framing; Framed or glued-laminated arches that spring from the top of walls or wall abutments</td>
<td>4b</td>
<td>6</td>
<td>3b</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. Spaced members shall be permitted to be composed of two or more pieces not less than 3 inches nominal in thickness where blocked solidly throughout their intervening spaces or where spaces are tightly closed by a continuous wood cover plate of not less than 2 inches nominal in thickness secured to the underside of the members. Splice plates shall be not less than 3 inches nominal in thickness.

b. Where protected by approved automatic sprinklers under the roof deck, framing members shall be not less than 3 inches nominal in width.

24.4.11.1 Details of heavy timber structural members.
Heavy timber structural members shall be detailed and constructed in accordance with Clauses 24.4.11.1 through 24.4.11.1.3.

24.4.11.1.1 Columns.
Minimum dimensions of columns shall be in accordance with Table 24.4.11. Columns shall be continuous or superimposed throughout all stories and connected in an approved manner. Girders and beams at column connections shall be closely fitted around columns and adjoining ends shall be cross tied to each other, or intertied by caps or ties, to transfer horizontal loads across joints. Wood bolsters shall not be placed on tops of columns unless the columns support roof loads only. Where traditional heavy timber detailing is used, connections shall be by means of reinforced concrete or metal caps with brackets, by properly designed steel or iron caps, with pintles and base plates, or by other approved methods.

24.4.11.1.2 Floor framing.
Minimum dimensions of floor framing shall be in accordance with Table 24.4.11. Approved wall plate boxes or hangers shall be provided where wood beams, girders or trusses rest on masonry or concrete walls. Where intermediate beams are used to support a floor, they shall rest on top of girders, or shall be supported by an approved metal hanger into which the ends of the beams shall be closely fitted. Where traditional heavy timber detailing is used, these connections shall be permitted to be supported by ledgers or blocks securely fastened to the sides of the girders.

760
24.4.11.1.3 Roof framing.

Minimum dimensions of roof framing shall be in accordance with Table 24.4.11. Every roof girder and not less than every alternate roof beam shall be anchored to its supporting member to resist forces as required in Part 17.

24.4.11.2 Partitions and walls.

Partitions and walls shall comply with Clause 24.4.11.2.1 or 24.4.11.2.2.

24.4.11.2.1 Exterior walls.

Exterior walls shall be permitted to be cross-laminated timber meeting the requirements of Clause 24.3.1.4.

24.4.11.2.2 Interior walls and partitions.

Interior walls and partitions shall be of solid wood construction formed by not less than two layers of 1-inch (25 mm) matched boards or laminated construction 4 inches (102 mm) thick, or of 1-hour fire-resistance-rated construction.

24.4.11.3 Floors.

Floors shall be without concealed spaces. Wood floors shall be constructed in accordance with Clause 24.4.11.3.1 or 24.4.11.3.2.

24.4.11.3.1 Cross-laminated timber floors.

Cross-laminated timber shall be not less than 102 mm (4 inches) in actual thickness. Cross-laminated timber shall be continuous from support to support and mechanically fastened to one another. Cross-laminated timber shall be permitted to be connected to walls without a shrinkage gap providing swelling or shrinking is considered in the design. Corbelling of masonry walls under the floor shall be permitted to be used.

24.4.11.3.2 Sawn or glued-laminated plank floors.

Sawn or glued-laminated plank floors shall be one of the following:

1. Sawn or glued-laminated planks, splined or tongue-and-groove, of not less than 76 mm (3 inches) nominal in thickness covered with 25 mm (1-inch) nominal dimension tongue-and-groove flooring, laid crosswise or diagonally, 12 mm (1/32-inch) wood structural panel or 12.7 mm (1/2-inch) particleboard.

2. Planks not less than 102 mm (4 inches) nominal in width set on edge close together and well spiked and covered with 1-inch (25 mm) nominal dimension flooring or 15/32-inch (12 mm) wood structural panel or 12.7 mm (1/2-inch) particleboard.

The timber shall be laid so that continuous lines of joints will occur only at points of support.

Floors shall not extend closer than 12.7 mm (1/2 inch) to walls. Such 12.7 mm (1/2-inch) space shall be covered by a molding fastened to the wall and so arranged that it will not obstruct the swelling or shrinkage movements of the floor. Corbelling of masonry walls under the floor shall be permitted to be used in place of molding.

24.4.11.4 Roof decks.

Roofs shall be without concealed spaces and roof decks shall be constructed in accordance with Clause 24.4.11.4.1 or 24.4.11.4.2. Other types of decking shall be an alternative that provides equivalent fire resistance and structural properties. Where supported by a wall, roof decks shall be anchored to walls to resist forces determined in accordance with Part 17. Such anchors shall consist of steel bolts, lags, screws or approved hardware of sufficient strength to resist prescribed forces.

24.4.11.4.1 Cross-laminated timber roofs.

Cross-laminated timber roofs shall be not less than 76 mm (3 inches) nominal in thickness and shall be continuous from support to support and mechanically fastened to one another.
24.4.11.4.2 Sawn, wood structural panel, or glued-laminated plank roofs.

Sawn, wood structural panel, or glued-laminated plank roofs shall be one of the following:

1. Sawn or glued laminated, splined or tongue-and-groove plank, not less than 51 mm (2 inches) nominal in thickness.
2. 32 mm -thick (1/8-inch) wood structural panel (exterior glue).
3. Planks not less than 76 mm (3 inches) nominal in width, set on edge close together and laid as required for floors.

24.4.12 Protection against decay and termites.

Wood shall be protected from decay and termites in accordance with the applicable provisions of Clauses 24.4.12.1 through 24.4.12.6.

24.4.12.1 Locations requiring waterborne preservatives or naturally durable wood.

Wood used above ground in the locations specified in Clauses 24.4.12.1.1 through 24.4.12.1.5, 24.4.12.3 and 24.4.12.5 shall be naturally durable wood or preservative-treated wood using waterborne preservatives, in accordance with GS 146-1 and 2 for above-ground use.

24.4.12.1.1 Joists, girders and subfloor.

Wood joists or wood structural floors that are closer than 457 mm (18 inches) (or wood girders that are closer than 305 mm (12 inches) to the exposed ground in crawl spaces or unexcavated areas located within the perimeter of the building foundation shall be of naturally durable or preservative-treated wood.

24.4.12.1.2 Wood supported by exterior foundation walls.

Wood framing members, including wood sheathing, that are in contact with exterior foundation walls and are less than 203 mm (8 inches) from exposed earth shall be of naturally durable or preservative-treated wood.

24.4.12.1.3 Exterior walls below grade.

Wood framing members and furring strips in direct contact with the interior of exterior masonry or concrete walls below grade shall be of naturally durable or preservative-treated wood.

24.4.12.1.4 Sleepers and sills.

Sleepers and sills on a concrete or masonry slab that is in direct contact with earth shall be of naturally durable or preservative-treated wood.

24.4.12.1.5 Wood siding.

Clearance between wood siding and earth on the exterior of a building shall be not less than 152 mm (6 inches) or less than 51 mm (2 inches) vertical from concrete steps, porch slabs, patio slabs and similar horizontal surfaces exposed to the weather except where siding, sheathing and wall framing are of naturally durable or preservative-treated wood.

24.4.12.2 Other locations.

Wood used in the locations specified in Clauses 24.4.12.2.1 through 24.4.12.2.5 shall be naturally durable wood or preservative-treated wood in accordance with AWPA U1. Preservative-treated wood used in interior locations shall be protected with two coats of urethane, shellac, latex epoxy or varnish unless waterborne preservatives are used. Prior to application of the protective finish, the wood shall be dried in accordance with the manufacturer’s recommendations.

24.4.12.2.1 Girder ends.

The ends of wood girders entering exterior masonry or concrete walls shall be provided with
a \( \frac{1}{2} \)-inch (12.7 mm) airspace on top, sides and end, unless naturally durable or preservative-treated wood is used.

### 24.4.12.2.2 Posts or columns.

Posts or columns supporting permanent structures and supported by a concrete or masonry slab or footing that is in direct contact with the earth shall be of naturally durable or preservative-treated wood.

**Exception:** Posts or columns that meet all of the following:

1. Are not exposed to the weather, or are protected by a roof, eave, overhang, or other covering if exposed to the weather.

2. Are supported by concrete piers or metal pedestals projected not less than 25 mm (1 inch) above the slab or deck and are separated from the concrete pier by an impervious moisture barrier.

3. Are located not less than 203 mm (8 inches) above exposed earth.

### 24.4.12.2.3 Supporting member for permanent appurtenances.

Naturally durable or preservative-treated wood shall be utilized for those portions of wood members that form the structural supports of buildings, balconies, porches or similar permanent building appurtenances where such members are exposed to the weather without adequate protection from a roof, eave, overhang or other covering to prevent moisture or water accumulation on the surface or at joints between members.

### 24.4.12.2.4 Laminated timbers.

The portions of glued-laminated timbers that form the structural supports of a building or other structure and are exposed to weather and not fully protected from moisture by a roof, eave or similar covering shall be pressure treated with preservative or be manufactured from naturally durable or preservative-treated wood.

### 24.4.12.2.5 Supporting members for permeable floors and roofs.

Wood structural members that support moisture-permeable floors or roofs that are exposed to the weather, such as concrete or masonry slabs, shall be of naturally durable or preservative-treated wood unless separated from such floors or roofs by an impervious moisture barrier. The impervious moisture barrier system protecting the structure supporting floors shall provide positive drainage of water that infiltrates the moisture-permeable floor topping.

### 24.4.12.2.6 Ventilation beneath balcony or elevated walking surfaces.

Enclosed framing in exterior balconies and elevated walking surfaces that are exposed to rain, drainage from irrigation shall be provided with openings that provide a net free cross-ventilation area not less than \( \frac{1}{150} \) of the area of each separate space.

### 24.4.12.3 Wood in contact with the ground or fresh water.

Wood used in contact with exposed earth shall be naturally durable for both decay and termite resistance or preservative treated in accordance with GS 146-1 and 2 for soil or fresh water use.

### 24.4.12.3.1 Posts or columns.

Posts and columns that are supporting permanent structures and embedded in concrete that is exposed to the weather or in direct contact with the earth shall be of preservative-treated wood.

### 24.4.12.4 Termite protection.

In geographical areas where hazard of termite damage is known to be very heavy, wood floor framing in the locations specified in Clause 24.4.12.1.1 and exposed framing of exterior decks or balconies shall be of naturally durable species (termite resistant) or preservative treated in accordance with AWPA U1 for the species, product preservative and end use or provided with approved methods of termite protection.
24.4.12.5 Wood used in retaining walls and cribs.
Wood installed in retaining or crib walls shall be preservative treated in accordance with AWPA U1 for soil and fresh water use.

24.4.12.6 Attic ventilation.
For attic ventilation, see GS 1119

24.4.12.6 Under-floor ventilation (crawl space).
For under-floor ventilation (crawl space).

24.4.13 Long-term loading.
Wood members supporting concrete, masonry or similar materials shall be checked for the effects of long-term loading using the provisions of the ANSI/AWC NDS. The total deflection, including the effects of long-term loading, shall be limited in accordance with Clause 17.4.3.1 for these supported materials.

Exception: Horizontal wood members supporting masonry or concrete nonstructural floor or roof surfacing not more than 102 mm (4 inches) thick need not be checked for long-term loading.

24.5 GENERAL DESIGN REQUIREMENTS
FOR LATERAL FORCE-RESISTING SYSTEMS

24.5.1 General.
Structures using wood-frame shear walls or wood-frame diaphragms to resist wind, seismic or other lateral loads shall be designed and constructed in accordance with AWC SDPWS and the applicable provisions of Clauses 24.5, 24.6 and 24.7.

24.5.1.1 Openings in shear panels.
Openings in shear panels that materially affect their strength shall be detailed on the plans and shall have their edges adequately reinforced to transfer all shearing stresses.

24.5.2 Diaphragm deflection.
The deflection of wood-frame diaphragms shall be determined in accordance with AWC SDPWS. The deflection ($\Delta_{dia}$) of a blocked wood structural panel diaphragm uniformly fastened throughout with staples is permitted to be calculated in accordance with Equation 24-1. If not uniformly fastened, the constant 0.188 (For SI: $\frac{1}{1627}$) in the third term shall be modified by an approved method.

$$\Delta_{dia} = \frac{5vL^3}{8EAW} + \frac{vL}{4Gt} + 0.188Le_n + \frac{\Sigma(x\Delta_c)}{2W}$$

(Equation 24-1)

For SI:

$$\Delta_{dia} = 0.052vL^3/EAW + \frac{vL}{4Gt} + \frac{Le}{1627} + \frac{\Sigma(x\Delta_c)}{2W}$$

Where:

- $A =$ Area of chord cross clause, in square inches ($mm^2$).
- $E =$ Modulus of elasticity of diaphragm chords, in pounds per square inch (N/mm$^2$).
- $E_n =$ Staple slip, in inches (mm) [see Table 2305.2(1)].
- $Gt =$ Panel rigidity through the thickness, in pounds per inch (N/mm) of panel width or depth [see Table 2305.2(2)].
- $L =$ Diaphragm length (dimension perpendicular to the direction of the applied load), in feet (mm).
\[ v = \text{Induced unit shear in pounds per linear foot (plf) (N/mm)}. \]

Diaphragm width [in the direction of applied force, in feet (mm)].

\[ W = \text{Distance from chord splice to nearest support, in feet (mm)}. \]

Diaphragm chord splice slip at the induced unit shear, in inches (mm).

\[ \Delta_c = \text{Maximum mid-span diaphragm deflection determined by elastic analysis, in inches (mm)}. \]

\[ \Delta_{\text{dia}} = \] AND SHEAR WALL DEFLECTION DUE TO FASTENER SLIP (Structural I)\(^a, c\)

<table>
<thead>
<tr>
<th>LOAD PER (^b) FASTENER (pounds)</th>
<th>FASTENER DESIGNATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.011</td>
</tr>
<tr>
<td>80</td>
<td>0.018</td>
</tr>
<tr>
<td>100</td>
<td>0.028</td>
</tr>
<tr>
<td>120</td>
<td>0.04</td>
</tr>
<tr>
<td>140</td>
<td>0.053</td>
</tr>
<tr>
<td>160</td>
<td>0.068</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.448 N.

\(^a\) Increase \( e_n \) values 20 percent for plywood grades other than Structural I.

\(^b\) Load per fastener = maximum shear per foot divided by the number of fasteners per foot at interior panel edges.

\(^c\) Decrease \( e_n \) values 50 percent for seasoned timber (moisture content < 19 percent).

\[ \] TABLE 24.5.2(1) \( e_n \) VALUES (inches) FOR USE IN CALCULATING DIAPHRAGM
### TABLE 24.5.2(2) VALUES OF $G_t$ FOR USE IN CALCULATING DEFLECTION OF WOOD STRUCTURAL PANEL SHEAR WALLS AND DIAPHRAGMS

<table>
<thead>
<tr>
<th>PANEL TYPE</th>
<th>SPAN RATING</th>
<th>3-ply</th>
<th>4-ply</th>
<th>5-ply*</th>
<th>3-ply</th>
<th>4-ply</th>
<th>5-ply*</th>
<th>3-ply</th>
<th>4-ply</th>
<th>5-ply*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheathing</td>
<td>24/0</td>
<td>25,000</td>
<td>32,500</td>
<td>37,500</td>
<td>77,500</td>
<td>32,500</td>
<td>42,500</td>
<td>41,500</td>
<td>41,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24/16</td>
<td>27,000</td>
<td>35,000</td>
<td>40,500</td>
<td>83,500</td>
<td>35,000</td>
<td>45,500</td>
<td>44,500</td>
<td>83,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32/20</td>
<td>27,000</td>
<td>35,000</td>
<td>40,500</td>
<td>83,500</td>
<td>35,000</td>
<td>45,500</td>
<td>44,500</td>
<td>83,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40/20</td>
<td>28,500</td>
<td>37,000</td>
<td>43,000</td>
<td>88,500</td>
<td>37,000</td>
<td>48,000</td>
<td>47,500</td>
<td>88,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>48/24</td>
<td>31,000</td>
<td>40,500</td>
<td>46,500</td>
<td>96,000</td>
<td>40,500</td>
<td>52,500</td>
<td>51,000</td>
<td>96,000</td>
<td></td>
</tr>
<tr>
<td>Single Floor</td>
<td>16 o.c.</td>
<td>27,000</td>
<td>35,000</td>
<td>40,500</td>
<td>83,500</td>
<td>35,000</td>
<td>45,500</td>
<td>44,500</td>
<td>83,500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 o.c.</td>
<td>30,000</td>
<td>39,000</td>
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<td>93,000</td>
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<td>50,500</td>
<td>49,500</td>
<td>93,000</td>
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</tr>
<tr>
<td></td>
<td>32 o.c.</td>
<td>36,000</td>
<td>47,000</td>
<td>54,000</td>
<td>110,000</td>
<td>47,000</td>
<td>61,000</td>
<td>59,500</td>
<td>110,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>48 o.c.</td>
<td>50,500</td>
<td>65,500</td>
<td>76,000</td>
<td>155,000</td>
<td>65,500</td>
<td>85,000</td>
<td>83,500</td>
<td>155,000</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness (in)</th>
<th>Structural Sheathing</th>
<th>Structural I</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1/4$</td>
<td>A-A</td>
<td>A-C</td>
</tr>
<tr>
<td></td>
<td>Marine</td>
<td>All Other Grades</td>
</tr>
<tr>
<td>$11/12$</td>
<td>25,500</td>
<td>33,000</td>
</tr>
<tr>
<td>$5/8$</td>
<td>26,000</td>
<td>34,000</td>
</tr>
<tr>
<td>$13/16$</td>
<td>38,000</td>
<td>49,500</td>
</tr>
<tr>
<td>$1/4$</td>
<td>38,500</td>
<td>50,000</td>
</tr>
<tr>
<td>$13/16$</td>
<td>49,000</td>
<td>63,500</td>
</tr>
<tr>
<td>$13/16$</td>
<td>49,500</td>
<td>64,500</td>
</tr>
<tr>
<td>$31/32$</td>
<td>50,500</td>
<td>65,500</td>
</tr>
<tr>
<td>$1/4$</td>
<td>51,000</td>
<td>66,500</td>
</tr>
<tr>
<td>$1/4$</td>
<td>52,500</td>
<td>68,500</td>
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<tr>
<td>1</td>
<td>73,500</td>
<td>93,500</td>
</tr>
<tr>
<td>1</td>
<td>73,500</td>
<td>92,500</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 pound/inch = 0.1751 N/mm.

a. 5-ply applies to plywood with five or more layers. For 5-ply plywood with three layers, use values for 4-ply panels.
24.5.3 Shear wall deflection.

The deflection of wood-frame shear walls shall be determined in accordance with EN 310. The deflection ($\Delta_{sw}$) of a blocked wood structural panel shear wall uniformly fastened throughout with staples is permitted to be calculated in accordance with Equation 24-2.

$$\Delta_{sw} = \frac{8vh^3}{EAb} + \frac{vh}{4Gt} + 0.75he + d_a h/b$$

For SI:

$$vh^3/3EAb + vh/Gt + \frac{ke_a}{407.6} + d_a h/b$$

Where:

- $A$ = Area of end-post cross clause in square inches (mm$^2$).
- $b$ = Shear wall length, in feet (mm).
- $d_a$ = Total vertical elongation of wall anchorage system (such as fastener slip, device elongation, rod elongation) at the induced unit shear in the shear wall ($v$).
- $E$ = Modulus of elasticity of end posts, in pounds per square inch (N/mm$^2$).
- $e_n$ = Staple slip, in inches (mm) [see Table 2305.2(1)].
- $Gt$ = Panel rigidity through the thickness, in pounds per inch (N/mm) of panel width or depth [see Table 2305.2(2)].
- $h$ = Shear wall height, in feet (mm).
- $v$ = Induced unit shear, in pounds per linear foot (N/mm).
- $\Delta_{sw}$ = Maximum shear wall deflection determined by elastic analysis, in inches (mm).

24.6 ALLOWABLE STRESS DESIGN

24.6.1 Allowable stress design.

The design and construction of wood elements in structures using allowable stress design shall be in accordance with the following applicable standards:

- ANSI/AWC Code of practice for Wood Construction
- NDS BRRI-Code of practice—Special Design Provisions for Structural Wind Loads and Seismic Design

APA—The Engineered Wood Association.

- ANSI 117 Standard Specifications for Structural Glued Laminated Timber of Softwood Species
- ANSI A190.1 Structural Glued Laminated Timber Panel Design Specification
- Plywood Design Specification Supplement 1—Design & Fabrication of Plywood Curved Panel
- Plywood Design Specification Supplement 2—Design & Fabrication of Glued Plywood-timber Beams
- Plywood Design Specification Supplement 3—Design & Fabrication of Plywood Stressed-skin Panels
- Plywood Design Specification Supplement 4—Design & Fabrication of Plywood Sandwich Panels
- Plywood Design Specification Supplement 5—Design & Fabrication of All-plywood Beams

Truss Plate Institute, Inc.

- TPI 1 National Design Standard for Metal Plate Connected Wood Truss Construction

West Coast Timber Inspection Bureau

- AITC 104 Typical Construction Details
- AITC Standard Appearance Grades for
24.6.1.1 Joists and rafters.  
The design of rafter spans is permitted to be in accordance with the AWC STJR.

24.6.1.2 Plank and beam flooring.  
The design of plank and beam flooring is permitted to be in accordance with the AWC Wood Construction Data No. 4.

24.6.1.3 Treated wood stress adjustments.  
The allowable unit stresses for preservative-treated wood need not be adjusted for treatment, but are subject to other adjustments. The allowable unit stresses for fire-retardant-treated wood, including fastener values, shall be developed from an approved method of investigation that considers the effects of anticipated temperature and humidity to which the fire-retardant-treated wood will be subjected, the type of treatment and the redrying process. Other adjustments are applicable except that the impact load duration shall not apply.

24.6.1.4 Timber decking.  
The capacity of timber decking arranged according to the patterns described in Clause 24.4.9.2 shall be the lesser of the capacities determined for flexure and deflection according to the formulas in Table 24.6.1.4.

### TABLE 24.6.1.4  
ALLOWABLE LOADS FOR TIMBER DECKING

<table>
<thead>
<tr>
<th>PATTERN</th>
<th>ALLOWABLE AREA LOAD</th>
<th>( \sigma_b )</th>
<th>( \sigma_\Delta )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flexure</td>
<td>( \frac{8F_b'd^2}{l^6} )</td>
<td>( \frac{384\Delta E \varepsilon l^3}{l^4} )</td>
</tr>
<tr>
<td></td>
<td>Deflection</td>
<td>( \frac{8F_b'd^2}{l^6} )</td>
<td>( \frac{185\Delta E \varepsilon l^3}{l^4} )</td>
</tr>
<tr>
<td>Simple span</td>
<td></td>
<td>( \frac{8F_b'd^2}{l^6} )</td>
<td>( \frac{131\Delta E \varepsilon l^3}{l^4} )</td>
</tr>
<tr>
<td>Two-span continuous</td>
<td></td>
<td>( \frac{20F_b'd^2}{3l^6} )</td>
<td>( \frac{105\Delta E \varepsilon l^3}{l^4} )</td>
</tr>
<tr>
<td>Combination</td>
<td></td>
<td>( \frac{20F_b'd^2}{3l^6} )</td>
<td>( \frac{105\Delta E \varepsilon l^3}{l^4} )</td>
</tr>
<tr>
<td>simple- and two-span</td>
<td></td>
<td>( \frac{116\Delta E \varepsilon l^3}{l^4} )</td>
<td></td>
</tr>
<tr>
<td>Cantilevered</td>
<td></td>
<td>( \frac{116\Delta E \varepsilon l^3}{l^4} )</td>
<td></td>
</tr>
<tr>
<td>pieces intermixed</td>
<td></td>
<td>( \frac{116\Delta E \varepsilon l^3}{l^4} )</td>
<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.  
a. \( \sigma_b \) = Allowable total uniform load limited by bending.  
\( \sigma \) = Allowable total uniform load limited by deflection.  
\( \Delta \) = Span of decking.  
\( F_b' \) = Allowable bending stress adjusted by applicable factors.  
\( E' \) = Modulus of elasticity adjusted by applicable factors.  

24.6.2 Wood-frame diaphragms.  
Wood-frame diaphragms shall be designed and constructed in accordance with AWC SDPWS. Where panels are fastened to framing members with staples, requirements and limitations of AWC
SDPWS shall be met and the allowable shear values set forth in Table 24.6.2(1) or 24.6.2(2) shall be permitted. The allowable shear values in Tables 24.6.2(1) and 24.6.2(2) are permitted to be increased 40 percent for wind design.

**TABLE 24.6.2(1) ALLOWABLE SHEAR VALUES (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL DIAPHRAGMS UTILIZING STAPLES WITH FRAMING OF DOUGLAS FIR-LARCH, OR SOUTHERN PINEa FOR WIND OR SEISMIC LOADINGf**

<table>
<thead>
<tr>
<th>PANEL GRADE</th>
<th>STAPLE LENGTH AND GAGEa</th>
<th>MINIMUM PENETRATION IN FRAMING (inches)</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (inch)</th>
<th>MINIMUM NOMINAL WIDTH OF FRAMING MEMBERS AT ADJOINING PANEL EDGES AND BOUNDARIES* (inches)</th>
<th>BLOCKED DIAPHRAGMS</th>
<th>UNBLOCKED DIAPHRAGMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural 1 grades</td>
<td>1\²/₁₆ gage</td>
<td>1 \²/₆</td>
<td>2</td>
<td>175</td>
<td>235</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 \²/₁₂</td>
<td>200</td>
<td>265</td>
<td>395</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₆</td>
<td>200</td>
<td>265</td>
<td>395</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₄</td>
<td>160</td>
<td>210</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₅</td>
<td>180</td>
<td>235</td>
<td>355</td>
</tr>
<tr>
<td>Sheathing, single floor and other grades covered in DOCS 1 and 2</td>
<td>1\²/₁₆ gage</td>
<td>1 \²/₆</td>
<td>2</td>
<td>165</td>
<td>225</td>
<td>335</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 \²/₁₂</td>
<td>190</td>
<td>250</td>
<td>375</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₄</td>
<td>160</td>
<td>210</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₅</td>
<td>180</td>
<td>235</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₆</td>
<td>175</td>
<td>235</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\²/₇</td>
<td>200</td>
<td>265</td>
<td>395</td>
</tr>
</tbody>
</table>

*Fasteners spaced 6 max. at supported edgesb

**CASE 1 Lead**

CASE 3

CASE 4

CASE 5

CASE 6

Framing

Blocking

Continuous panel joints

Diaphragm boundary

Continuous panel joints

769
Note: For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. For framing of other species: (1) Find specific gravity for species of timber in ANSI/AWC NDS. (2) For staples, find shear value from table for Structural I panels (regardless of actual grade) and multiply value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species.

b. Fastening along intermediate framing members: Space fasteners not greater than 12 inches on center, except 6 inches on center for spans greater than 32 inches.

c. Panels conforming to PS 1 or PS 2.

d. This table gives shear values for Cases 1 and 2 as shown in Table 2306.2(1). The values shown are applicable to Cases 3, 4, 5 and 6 as shown in Table 2306.2(1), providing fasteners at all continuous panel edges are spaced in accordance with the boundary fastener spacing.

e. The minimum nominal depth of framing members shall be 3 inches nominal. The minimum nominal width of framing members not located at boundaries or adjoining panel edges shall be 2 inches.

### TABLE 24.6.2(2) ALLOWABLE SHEAR VALUES (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL BLOCKED DIAPHRAGMS UTILIZING MULTIPLE ROWS OF STAPLES (HIGH-LOAD DIAPHRAGMS) WITH FRAMING OF DOUGLAS FIR-LARCH OR SOUTHERN PINE:^a FOR WIND OR SEISMIC LOADING ^b, g, h

<table>
<thead>
<tr>
<th>PANEL GRADE</th>
<th>STAPLE GAGE</th>
<th>MINIMUM FASTENER PENETRATION IN FRAMING (inches)</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (inch)</th>
<th>MINIMUM NOMINAL WIDTH OF FRAMING MEMBER AT ADJOINING PANEL EDGES AND BOUNDARIES^e</th>
<th>LINES OF FASTENERS</th>
<th>BLOCKED DIAPHRAGMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural grades</td>
<td>14 gage staples</td>
<td>2</td>
<td>15/32</td>
<td>3</td>
<td>2</td>
<td>600 600 860 960 1,060 1,200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19/32</td>
<td>3</td>
<td>2</td>
<td>600 600 875 960 1,075 1,200</td>
</tr>
<tr>
<td>Sheathing and other grades</td>
<td>14 gage staples</td>
<td>2</td>
<td>15/32</td>
<td>3</td>
<td>2</td>
<td>540 540 735 865 915 1,080</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>19/32</td>
<td>3</td>
<td>2</td>
<td>600 600 865 960 1,065 1,200</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. For framing of other species: (1) Find specific gravity for species of timber in ANSI/AWC NDS. (2) For staples, find shear value from table for Structural I panels (regardless of actual grade) and multiply value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species.

b. Fastening along intermediate framing members: Space fasteners not greater than 12 inches on center, except 6 inches on center for spans greater than 32 inches.

c. Panels conforming to PS 1 or PS 2.

d. This table gives shear values for Cases 1 and 2 as shown in Table 2306.2(1). The values shown are applicable to Cases 3, 4, 5 and 6 as shown in Table 2306.2(1), providing fasteners at all continuous panel edges are spaced in accordance with the boundary fastener spacing.

e. The minimum nominal depth of framing members shall be 3 inches nominal. The minimum nominal width of framing members not located at boundaries or adjoining panel edges shall be 2 inches.
f. Staples shall have a minimum crown width of \( \frac{7}{16} \) inch, and shall be installed with their crowns parallel to the long dimension of the framing members.

g. High-load diaphragms shall be subject to special inspection in accordance with Clause 19.5.5.1.

h. For shear loads of normal or permanent load duration as defined by the ANSI/AWC NDS, the values in the table shall be multiplied by 0.63 or 0.56, respectively.

(Continued)

TABLE 24.6.2(2)—continued ALLOWABLE SHEAR VALUES (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL BLOCKED DIAPHRAGMS UTILIZING MULTIPLE ROWS OF STAPLES (HIGH-LOAD DIAPHRAGMS) WITH FRAMING OF DOUGLAS FIR-LARCH OR SOUTHERN PINE FOR WIND OR SEISMIC LOADING

Note: Space panel end and edge joint 1/8 inch. Reduce spacing between lines of nails as necessary to maintain minimum 3/8 inch fasterner edge margins, minimum spacing between lines is 3/8 inch.
24.6.2.1 Gypsum board diaphragm ceilings.
Gypsum board diaphragm ceilings shall be in accordance with Clause 26.8.6.

2306.3 Wood-frame shear walls.
Wood-frame shear walls shall be designed and constructed in accordance with AWC SDPWS. Where panels are fastened to framing members with staples, requirements and limitations of AWC SDPWS shall be met and the allowable shear values set forth in Table 24.6.3(1), 24.6.3(2) or 24.6.3(3) shall be permitted. The allowable shear values in Tables 24.6.3(1) and 24.6.3(2) are permitted to be increased 40 percent for wind design. Panels complying with ANSI/APA PRP-210 shall be permitted to use design values for Plywood Siding in the AWC SDPWS.

### TABLE 24.6.3(1) ALLOWABLE SHEAR VALUES (POUNDS PER FOOT) FOR WOOD STRUCTURAL PANEL SHEAR WALLS UTILIZING STAPLES WITH FRAMING OF DOUGLAS FIR-LARCH OR SOUTHERN PINEa FOR WIND OR SEISMIC LOADINGb, f, g, i

<table>
<thead>
<tr>
<th>PANEL GRADE</th>
<th>MINIMUM NOMINAL PANEL THICKNESS (inch)</th>
<th>MINIMUM FASTENER PENETRATION IN FRAMING (inches)</th>
<th>PANELS APPLIED DIRECT TO FRAMING</th>
<th>PANELS APPLIED OVER 1/2&quot; OR 5/8&quot; GYPSUM SHEATHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Staple length and gage h (inches)</td>
<td>Fastener spacing at panel edges (inches)</td>
</tr>
<tr>
<td>Structural sheathing</td>
<td>3/8</td>
<td>1</td>
<td>1 1/2 16 Gage</td>
<td>155 235 315 400</td>
</tr>
<tr>
<td></td>
<td>7/16</td>
<td></td>
<td></td>
<td>170 260 345 440</td>
</tr>
<tr>
<td></td>
<td>15/32</td>
<td></td>
<td></td>
<td>185 280 375 475</td>
</tr>
<tr>
<td>Structural sheathing, plywood sidingg except Group 5 species, ANSI/APA PRP-10</td>
<td>5/16 or 1/4</td>
<td>1</td>
<td>1 1/2 16 Gage</td>
<td>145 220 295 375</td>
</tr>
<tr>
<td></td>
<td>3/8</td>
<td></td>
<td></td>
<td>140 210 280 360</td>
</tr>
<tr>
<td></td>
<td>7/16</td>
<td></td>
<td></td>
<td>155 230 310 395</td>
</tr>
<tr>
<td></td>
<td>15/32</td>
<td></td>
<td></td>
<td>170 255 335 430</td>
</tr>
<tr>
<td></td>
<td>19/32</td>
<td></td>
<td></td>
<td>185 280 375 475</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. For framing of other species: (1) Find specific gravity for species of timber in ANSI/AWC NDS. (2) For staples find shear value from table for Structural I panels (regardless of actual grade) and multiply value by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species.

b. Panel edges backed with 2-inch nominal or wider framing. Install panels either horizontally or vertically. Space fasteners maximum 6 inches on center along intermediate framing members for 3/8-inch and 7/16-inch panels installed on studs spaced 24 inches on center. For other conditions and panel thickness, space fasteners maximum 12 inches on center on intermediate supports.
c. \( \frac{3}{8} \)-inch panel thickness or siding with a span rating of 16 inches on center is the minimum recommended where applied directly to framing as exterior siding. For grooved panel siding, the nominal panel thickness is the thickness of the panel measured at the point of fastening.

d. Framing at adjoining panel edges shall be 3 inches nominal or wider.

e. Values apply to all-veneer plywood. Thickness at point of fastening on panel edges governs shear values.

f. Where panels are applied on both faces of a wall and fastener spacing is less than 6 inches on center on either side, panel joints shall be offset to fall on different framing members, or framing shall be 3 inches nominal or thicker at adjoining panel edges.

g. In Seismic Design Category D, E or F, where shear design values exceed 350 pounds per linear foot, all framing members receiving edge fastening from abutting panels shall be not less than a single 3-inch nominal member, or two 2-inch nominal members fastened together in accordance with Clause 24.6.1 to transfer the design shear value between framing members. Wood structural panel joint and sill plate nailing shall be staggered at panel edges. See AWC SDPWS for sill plate size and anchorage requirements.

h. Staples shall have a minimum crown width of \( \frac{7}{16} \) inch and shall be installed with their crowns parallel to the long dimension of the framing members.

i. For shear loads of normal or permanent load duration as defined by the ANSI/AWC NDS, the values in the table shall be multiplied by 0.63 or 0.56, respectively.

### TABLE 24.6.3(2) ALLOWABLE SHEAR VALUES (plf) FOR WIND OR SEISMIC LOADING ON SHEAR WALLS OF FIBREBOARD SHEATHING BOARD CONSTRUCTION UTILIZING STAPLES FOR TYPE V CONSTRUCTION ONLYa, b, c, d, e

<table>
<thead>
<tr>
<th>THICKNESS AND GRADE (inches)</th>
<th>STAPLE GAGE AND DIMENSIONS</th>
<th>ALLOWABLE SHEAR VALUE (pounds per linear foot) STAPLE SPACING AT PANEL EDGES (inches)(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 or 25/32 Structural</td>
<td>No. 16 gage galvanized staple, ( \frac{7}{16} ) inch long, crown 3/4 inch long</td>
<td>150 200 225</td>
</tr>
<tr>
<td></td>
<td>No. 16 gage galvanized staple, 1 1/4 inch long</td>
<td>220 290 325</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.5939 N/m.

a. Fibreboard sheathing shall not be used to brace concrete or masonry walls.

b. Panel edges shall be backed with 2-inch or wider framing of Douglas Fir-larch or Southern Pine. For framing of other species:
   (1) Find specific gravity for species of framing timber in ANSI/AWC NDS. (2) For staples, multiply the shear value from the table by 0.82 for species with specific gravity of 0.42 or greater, or 0.65 for all other species.

c. Values shown are for fibreboard sheathing on one side only with long panel dimension either parallel or perpendicular to studs.

d. Fastener shall be spaced 6 inches on center along intermediate framing members.

e. Values are not permitted in Seismic Design Category D, E or F.
### TABLE 24.6.3(3) ALLOWABLE SHEAR VALUES FOR WIND OR SEISMIC FORCES FOR SHEAR WALLS OF LATH AND PLASTER OR GYPSUM BOARD WOOD FRAMED WALL ASSEMBLIES UTILIZING STAPLES

<table>
<thead>
<tr>
<th>TYPE OF MATERIAL</th>
<th>THICKNESS OF MATERIAL</th>
<th>WALL CONSTRUCTION</th>
<th>STAPLE SPACING* MAXIMUM (inches)</th>
<th>SHEAR VALUE+ (pfl)</th>
<th>MINIMUM STAPLE SIZE</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Expanded metal or woven wire lath and Portland cement plaster</td>
<td>$\frac{7}{8}''$</td>
<td>Unblocked</td>
<td>6</td>
<td>180</td>
<td>No. 16 gage galv. staple, $\frac{7}{8}''$ legs</td>
<td></td>
</tr>
<tr>
<td>2. Gypsum lath, plain or perforated</td>
<td>$\frac{7}{8}''$ lath and $\frac{1}{2}''$ plaster</td>
<td>Unblocked</td>
<td>5</td>
<td>100</td>
<td>No. 16 gage galv. staple, $\frac{1}{4}''$ long</td>
<td></td>
</tr>
<tr>
<td>3. Gypsum sheathing</td>
<td>2'' x 2'' x 8''</td>
<td>Blocked$^{d}$</td>
<td>4</td>
<td>75</td>
<td>No. 16 gage galv. staple, $\frac{3}{4}''$ long</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\frac{1}{2}''$ x 4''</td>
<td>Unblocked</td>
<td>7</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gypsum board, gypsum veneer base or water-resistant gypsum backing board</td>
<td>$\frac{1}{2}''$</td>
<td>Unblocked$^{f}$</td>
<td>7</td>
<td>75</td>
<td>No. 16 gage galv. staple, $\frac{1}{2}''$ long</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unblocked</td>
<td>4</td>
<td>110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unblocked</td>
<td>7</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocked$^{e}$</td>
<td>4</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocked$^{e}$</td>
<td>7</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blocked$^{e}$</td>
<td>4</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Base ply: 9 Face ply: 7</td>
<td>7</td>
<td>115</td>
<td>No. 16 gage galv. staple, $\frac{3}{4}''$ long</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two-ply</td>
<td>4</td>
<td>145</td>
<td>No. 15 gage galv. staple, $\frac{1}{4}''$ long</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per foot = 14.5939 N/m.

- **a.** These shear walls shall not be used to resist loads imposed by masonry or concrete walls (see AWC SDPWS). Values shown are for short-term loading due to wind or seismic loading. Walls resisting seismic loads shall be subject to the limitations in Clause 12.2.1 of ASCE 7. Values shown shall be reduced 25 percent for normal loading.
- **b.** Applies to fastening at studs, top and bottom plates and blocking.
- **c.** Except as noted, shear values are based on a maximum framing spacing of 16 inches on center.
- **d.** Maximum framing spacing of 24 inches on center.
- **e.** All edges are blocked, and edge fastening is provided at all supports and all panel edges.
- **f.** Staples shall have a minimum crown width of $\frac{7}{16}$ inch, measured outside the legs, and shall be installed with their crowns parallel to the long dimension of the framing members.
- **g.** Staples for the attachment of gypsum lath and woven-wire lath shall have a minimum crown width of $\frac{3}{4}$ inch, measured outside the legs.

### 24.7 LOAD AND RESISTANCE FACTOR DESIGN

**24.7.1 Load and resistance factor design.**

The design and construction of wood elements and structures using load and resistance factor design shall be in accordance with ANSI/AWC NDS and AWC SDPWS.

### 24.8 CONVENTIONAL LIGHT-FRAME CONSTRUCTION

**24.8.1 General.**

The requirements of this clause are intended for conventional light-frame construction. Other construction methods are permitted to be used, provided that a satisfactory design is submitted showing compliance with other provisions of this Code. Interior non-load-bearing partitions, ceilings and curtain walls of conventional light-frame construction are not subject to the limitations of Clause 24.8.2. Detached one- and two-family dwellings and
townhouses not more than three stories above grade plane in height with a separate means of escape and their accessory structures shall comply with the International Residential Code.

24.8.1.1 Portions exceeding limitations of conventional light-frame construction.

Where portions of a building of otherwise conventional light-frame construction exceed the limits of Clause 24.8.2, those portions and the supporting load path shall be designed in accordance with accepted engineering practice and the provisions of this Code. For the purposes of this clause, the term “portions” shall mean parts of buildings containing volume and area such as a room or a series of rooms. The extent of such design need only demonstrate compliance of the nonconventional light-framed elements with other applicable provisions of this Code and shall be compatible with the performance of the conventional light-framed system.

24.8.1.2 Connections and fasteners.

Connectors and fasteners used in conventional construction shall comply with the requirements of Clause 24.4.10.

24.8.2 Limitations.

Buildings are permitted to be constructed in accordance with the provisions of conventional light-frame construction, subject to the limitations in Clauses 24.8.2.1 through 24.8.2.6.

24.8.2.1 Stories.

Structures of conventional light-frame construction shall be limited in storey height in accordance with Table 24.8.2.1.

**TABLE 24.8.2.1 ALLOWABLE STOREY HEIGHT**

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>ALLOWABLE STOREY ABOVE GRADE PLANE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A and B</td>
<td>Three stories</td>
</tr>
<tr>
<td>C</td>
<td>Two stories</td>
</tr>
<tr>
<td>a</td>
<td>One storey</td>
</tr>
<tr>
<td>D and E</td>
<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

a. For the purposes of this clause, for buildings assigned to Seismic Design Category D or E, cripple walls shall be considered to be a storey unless cripple walls are solid blocked and do not exceed 14 inches in height.

24.8.2.2 Allowable floor-to-floor height.

Maximum floor-to-floor height shall not exceed 11 feet, 7 inches (3531 mm). Exterior bearing wall and interior braced wall height shall not exceed a stud height of 3048 mm (10 feet).

24.8.2.3 Allowable loads.

Loads shall be in accordance with Part 16 and shall not exceed the following:

1. Average dead loads shall not exceed 718 N/m² (15 psf) for combined roof and ceiling, exterior walls, floors and partitions.

   **Exceptions:**

   1. Subject to the limitations of Clause 24.8.6.10, stone or masonry veneer up to the lesser of 127 mm (5 inches) thick or 2395 N/m² (50 psf) and installed in accordance with Part 15 is permitted to a height of 9144 mm (30 feet) above a noncombustible foundation, with an additional 2438 mm (8 feet) permitted for gable ends.

2. Concrete or masonry fireplaces, heaters and chimneys shall be permitted in accordance with the provisions of this Code.

2. Live loads shall not exceed 1916 N/m² (40 psf) for floors.

   **Exception:** Live loads for concrete slab-on-ground floors in Risk Categories I and II shall be not more than 125 psf.

3. Ground snow loads shall not exceed 2395 N/m² (50 psf).

24.8.2.4 Basic wind speed.

V shall not exceed 130 miles per hour (57 m/s) (3-second gust).

**Exceptions:**

1. V shall not exceed 140 mph (61.6 m/s)

   (3-second gust) for buildings in Exposure Category B that are not located in a hurricane-prone region.

2. Where V exceeds 130 mph (3-second gust), the provisions of either AWC WFCM or ICC 600 are permitted to be used.
24.8.2.5 Allowable roof span.

Ceiling joist and rafter framing constructed in accordance with Clause 24.8.7 and trusses shall not span more than 1219 mm (40 feet) between points of vertical support. A ridge board in accordance with Clause 24.8.7 or 24.8.7.3.1 shall not be considered a vertical support.

24.8.2.6 Risk category limitation.

The use of the provisions for conventional light-frame construction in this clause shall not be permitted for Risk Category IV buildings assigned to Seismic Design Category B, C, D or F.

24.8.3 Foundations and footings.

Foundations and footings shall be designed and constructed in accordance with Part 18. Connections to foundations and footings shall comply with this clause.

24.8.3.1 Foundation plates or sills.

Foundation plates or sills resting on concrete or masonry foundations shall comply with Clause 24.4.3.1. Foundation plates or sills shall be bolted or anchored to the foundation with not less than 12.7 mm-diameter (1/2-inch) steel bolts or approved anchors spaced to provide equivalent anchorage as the steel bolts. Bolts shall be embedded not less than 178 mm (7 inches) into concrete or masonry. The bolts shall be placed between the plate washer and the nut. Foundations and footings shall be provided. The ends of beams or girders supported per piece with one bolt or anchor strap located not more than 305 mm (12 inches) or less than 102 mm (4 inches) from each end of each piece. Bolts in sill plates of braced wall lines in structures over two stories above grade shall be spaced not more than 1219 mm (4 feet) on center. A properly sized nut and washer shall be tightened on each bolt to the plate.

24.8.3.1.1 Braced wall line sill plate anchorage in Seismic Design Category D.

Sill plates along braced wall lines in buildings assigned to Seismic Design Category D shall be anchored with not less than 12.7 mm (1/2-inch) diameter anchor bolts with steel plate washers between the foundation sill plate and the nut, or approved anchor straps load-rated in accordance with Clause 24.4.10.3 and spaced to provide equivalent anchorage. Plate washers shall be not less than 5.82 mm by 76 mm by 76 mm (0.229 inch by 3 inches by 3 inches) in size. The hole in the plate washer is permitted to be diagonally splotted with a width of up to 4.76 mm (3/16 inch) larger than the bolt diameter and a splot length not to exceed 44 mm (1 3/4 inches), provided that a standard cut washer is placed between the plate washer and the nut.

24.8.3.1.2 Braced wall line sill plate anchorage in Seismic Design Category E.

Sill plates along braced wall lines in buildings assigned to Seismic Design Category E shall be anchored with not less than 15.9 mm diameter (5/8-inch) anchor bolts with steel plate washers between the foundation sill plate and the nut, or approved anchor straps load-rated in accordance with Clause 24.4.10.3 and spaced to provide equivalent anchorage. Plate washers shall be not less than 5.82 mm by 76 mm by 76 mm (0.229 inch by 3 inches by 3 inches) in size. The hole in the plate washer is permitted to be diagonally splotted with a width of up to 4.76 mm (3/16 inch) larger than the bolt diameter and a splot length not to exceed 44 mm (1 3/4 inches), provided that a standard cut washer is placed between the plate washer and the nut.

24.8.4 Floor framing.

Floor framing shall comply with this clause.

24.8.4.1 Girders.

Girders for single-storey construction or girders supporting loads from a single floor shall be not less than 102 mm by 152 mm (4 inches by 6 inches) for spans 1829 mm (6 feet) or less, provided that girders are spaced not more than 8 feet (2438 mm) on center. Other girders shall be designed to support the loads specified in this Code. Girder end joints shall occur over supports.

Where a girder is spliced over a support, an adequate tie shall be provided. The ends of beams or girders supported on masonry or concrete shall not have less than 76 mm (3 inches) of bearing.

24.8.4.1.1 Allowable girder spans.

The allowable spans of girders that are fabricated of dimension timber shall not exceed the values set forth in Table 24.8.4.1.1(1) or 24.8.4.1.1(2).
### TABLE 24.8.1.1(1) HEADER AND GIRDER SPANS

(For Exterior Bearing Walls)

<table>
<thead>
<tr>
<th>JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 6</td>
<td>2 x 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td>12</td>
<td>Douglas Fir-Larch</td>
<td>SS 12-6</td>
<td>16-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 12-0</td>
<td>15-10</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#2 11-10</td>
<td>15-7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 9-8</td>
<td>12-4</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS 11-10</td>
<td>15-7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 11-7</td>
<td>15-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 11-0</td>
<td>14-6</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#3 9-8</td>
<td>12-4</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS 12-3</td>
<td>16-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 11-10</td>
<td>15-7</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#2 11-3</td>
<td>14-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 9-2</td>
<td>11-6</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS 11-7</td>
<td>15-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 11-3</td>
<td>14-11</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#2 11-3</td>
<td>14-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 9-8</td>
<td>12-4</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 2308.4.1.1(1)—continued

**HEADER AND GIRDER SPANS**<sup>a, b</sup> **FOR EXTERIOR BEARING WALLS**

(Maximum spans for Douglas fir-larch, hem-fir, Southern pine and spruce-pine-fir<sup>b</sup> and required number of jack studs)

<table>
<thead>
<tr>
<th>JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 6</td>
<td>2 x 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td>19.2</td>
<td>Douglas Fir-Larch</td>
<td>SS</td>
<td>10-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>10-4</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#2</td>
<td>10-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS</td>
<td>10-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-10</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#2</td>
<td>9-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS</td>
<td>10-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>10-1</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#2</td>
<td>9-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS</td>
<td>9-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#2</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-7</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#2</td>
<td>9-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
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<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-2</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#2</td>
<td>8-9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>6-10</td>
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<td>Southern Pine</td>
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<td></td>
<td>#3</td>
<td>6-5</td>
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<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS</td>
<td>9-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>8-11</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#2</td>
<td>8-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>6-10</td>
</tr>
</tbody>
</table>
Note: For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are given in feet and inches.
b. Spans are based on minimum design properties for No. 2 grade timber of Douglas fir-larch, hem-fir, Southern pine and spruce-pine fir.
c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.
d. \(NJ = \) Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.
e. Use 30 psf ground snow load for cases in which ground snow load is less than 30 psf and the roof live load is equal to or less than 20 psf.
f. Spans are calculated assuming the top of the header or girder is laterally braced by perpendicular framing. Where the top of the header or girder is not laterally braced (for example, cripple studs bearing on the header), tabulated spans for headers consisting of 2 x 8, 2 x 10, or 2 x 12 sizes shall be multiplied by 0.70 or the header or girder shall be designed.

### TABLE 24.8.4.1.1(2)

**HEADER AND GIRDER SPANS\(^a,\)\(^b\) FOR INTERIOR BEARING WALLS**

(Maximum spans for Douglas fir-larch, hem-fir, Southern pine and spruce-pine-fir and required number of jack studs)

<table>
<thead>
<tr>
<th>HEADERS AND GIRDERS SUPPORTING</th>
<th>SIZE</th>
<th>BUILDING WIDTH(^c) (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Span</td>
</tr>
<tr>
<td>One floor only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-2 x 4</td>
<td></td>
<td>4-1</td>
</tr>
<tr>
<td>2-2 x 6</td>
<td></td>
<td>6-1</td>
</tr>
<tr>
<td>2-2 x 8</td>
<td></td>
<td>7-9</td>
</tr>
<tr>
<td>2-2 x 10</td>
<td></td>
<td>9-2</td>
</tr>
<tr>
<td>2-2 x 12</td>
<td></td>
<td>10-9</td>
</tr>
<tr>
<td>3-2 x 8</td>
<td></td>
<td>9-8</td>
</tr>
<tr>
<td>3-2 x 10</td>
<td></td>
<td>11-5</td>
</tr>
<tr>
<td>3-2 x 12</td>
<td></td>
<td>13-6</td>
</tr>
<tr>
<td>4-2 x 8</td>
<td></td>
<td>11-2</td>
</tr>
<tr>
<td>4-2 x 10</td>
<td></td>
<td>13-3</td>
</tr>
<tr>
<td>4-2 x 12</td>
<td></td>
<td>15-7</td>
</tr>
<tr>
<td>Two floors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-2 x 4</td>
<td></td>
<td>2-7</td>
</tr>
<tr>
<td>2-2 x 6</td>
<td></td>
<td>3-11</td>
</tr>
<tr>
<td>2-2 x 8</td>
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<td>5-0</td>
</tr>
<tr>
<td>2-2 x 10</td>
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<td>5-11</td>
</tr>
<tr>
<td>2-2 x 12</td>
<td></td>
<td>6-11</td>
</tr>
<tr>
<td>3-2 x 8</td>
<td></td>
<td>6-3</td>
</tr>
<tr>
<td>3-2 x 10</td>
<td></td>
<td>7-5</td>
</tr>
<tr>
<td>3-2 x 12</td>
<td></td>
<td>8-8</td>
</tr>
<tr>
<td>4-2 x 8</td>
<td></td>
<td>7-2</td>
</tr>
<tr>
<td>4-2 x 10</td>
<td></td>
<td>8-6</td>
</tr>
<tr>
<td>4-2 x 12</td>
<td></td>
<td>10-1</td>
</tr>
</tbody>
</table>
Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Spans are given in feet and inches.
b. Spans are based on minimum design properties for No. 2 grade timber of Douglas fir-larch, hem-fir, Southern pine and spruce-pine fir.
c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.
d. NJ = Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.
e. Spans are calculated assuming the top of the header or girder is laterally braced by perpendicular framing. Where the top of the header or girder is not laterally braced (for example, cripple studs bearing on the header), tabulated spans for headers consisting of 2 × 8, 2 × 10, or 2 × 12 sizes shall be multiplied by 0.70 or the header or girder shall be designed.

24.8.4.2 Floor joists.
Floor joists shall comply with this clause.

24.8.4.2.1 Span.
Spans for floor joists shall be in accordance with Table 24.8.4.2.1(1) or 24.8.4.2.1(2) or the AWC STJR.
<table>
<thead>
<tr>
<th>JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>$2\times 6$</th>
<th>$2\times 8$</th>
<th>$2\times 10$</th>
<th>$2\times 12$</th>
<th>$2\times 6$</th>
<th>$2\times 8$</th>
<th>$2\times 10$</th>
<th>$2\times 12$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
<td>(ft. – in.)</td>
</tr>
<tr>
<td>12</td>
<td>Douglas Fir-Larch</td>
<td>SS</td>
<td>11-4</td>
<td>15-0</td>
<td>19-1</td>
<td>23-3</td>
<td>11-4</td>
<td>15-0</td>
<td>19-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>10-11</td>
<td>14-5</td>
<td>18-5</td>
<td>22-0</td>
<td>10-11</td>
<td>14-2</td>
<td>17-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2</td>
<td>10-9</td>
<td>14-2</td>
<td>17-9</td>
<td>20-7</td>
<td>10-6</td>
<td>13-3</td>
<td>16-3</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#3</td>
<td>8-8</td>
<td>11-0</td>
<td>13-5</td>
<td>15-7</td>
<td>7-11</td>
<td>10-0</td>
<td>12-3</td>
</tr>
<tr>
<td></td>
<td>Henm-Fir</td>
<td>SS</td>
<td>10-9</td>
<td>14-2</td>
<td>18-0</td>
<td>21-11</td>
<td>10-9</td>
<td>14-2</td>
<td>18-0</td>
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<td>10-6</td>
<td>13-10</td>
<td>17-8</td>
<td>21-6</td>
<td>10-6</td>
<td>13-10</td>
<td>16-11</td>
</tr>
<tr>
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<td></td>
<td>#2</td>
<td>10-0</td>
<td>13-2</td>
<td>16-10</td>
<td>20-4</td>
<td>10-0</td>
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<td>16-0</td>
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<tr>
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<td>#3</td>
<td>8-8</td>
<td>11-0</td>
<td>13-5</td>
<td>15-7</td>
<td>7-11</td>
<td>10-0</td>
<td>12-3</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS</td>
<td>11-2</td>
<td>14-8</td>
<td>18-9</td>
<td>22-10</td>
<td>11-2</td>
<td>14-8</td>
<td>18-9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>10-9</td>
<td>14-2</td>
<td>18-0</td>
<td>21-11</td>
<td>10-9</td>
<td>14-2</td>
<td>16-11</td>
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<tr>
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<td>Southern Pine</td>
<td>#2</td>
<td>10-3</td>
<td>13-6</td>
<td>16-2</td>
<td>19-1</td>
<td>9-10</td>
<td>12-6</td>
<td>14-9</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#3</td>
<td>8-2</td>
<td>10-3</td>
<td>12-6</td>
<td>14-9</td>
<td>7-5</td>
<td>9-5</td>
<td>11-5</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS</td>
<td>10-6</td>
<td>13-10</td>
<td>17-8</td>
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<td>10-6</td>
<td>13-10</td>
<td>17-8</td>
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<td>10-3</td>
<td>13-6</td>
<td>17-3</td>
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<td>18-10</td>
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<td>13-5</td>
<td>15-7</td>
<td>7-11</td>
<td>10-0</td>
<td>12-3</td>
</tr>
<tr>
<td>16</td>
<td>Douglas Fir-Larch</td>
<td>SS</td>
<td>10-4</td>
<td>13-7</td>
<td>17-4</td>
<td>21-1</td>
<td>10-4</td>
<td>13-7</td>
<td>17-4</td>
</tr>
<tr>
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<td>#1</td>
<td>9-11</td>
<td>13-1</td>
<td>16-5</td>
<td>19-1</td>
<td>9-1</td>
<td>12-4</td>
<td>15-0</td>
</tr>
<tr>
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<td>#2</td>
<td>9-9</td>
<td>12-7</td>
<td>15-5</td>
<td>17-10</td>
<td>9-1</td>
<td>11-6</td>
<td>14-1</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#3</td>
<td>7-6</td>
<td>9-6</td>
<td>11-8</td>
<td>13-6</td>
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<td>8-8</td>
<td>10-7</td>
</tr>
<tr>
<td></td>
<td>Henm-Fir</td>
<td>SS</td>
<td>9-9</td>
<td>12-10</td>
<td>16-5</td>
<td>19-11</td>
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(Continued)
### TABLE 24.8.4.2.1(1)—continued

**FLOOR JOIST SPANS FOR COMMON TIMBER SPECIES**  
(Residential sleeping areas, live load = 30 psf, L/6 = 360)

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**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.  
**Note:** Check sources for availability of timber in lengths greater than 20 feet.
**TABLE 24.8.4.2.1(2)**

**FLOOR JOIST SPANS FOR COMMON TIMBER SPECIES**

(Residential living areas, live load = 40 psf, L/6 = 360)

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<td>6-5</td>
<td>8-2</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-4</td>
<td>12-3</td>
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<td>17-10</td>
<td>9-1</td>
<td>11-6</td>
<td>14-1</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#3</td>
<td>7-6</td>
<td>9-6</td>
<td>11-8</td>
<td>13-6</td>
<td>6-10</td>
<td>8-8</td>
<td>10-7</td>
</tr>
</tbody>
</table>
### TABLE 24.8.4.2.1(2)—continued

**FLOOR JOIST SPANS FOR COMMON TIMBER SPECIES**

(Residential living areas, live load = 40 psf, L/2 = 360)

<table>
<thead>
<tr>
<th>JOIST SPACING (Inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 6</td>
<td>2 x 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft.-in.)</td>
<td>(ft.-in.)</td>
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<tr>
<td></td>
<td></td>
<td>Maximum floor joist spans</td>
<td></td>
</tr>
<tr>
<td>19.2</td>
<td>Douglas Fir-Larch</td>
<td>SS</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2</td>
<td>9-1</td>
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<tr>
<td></td>
<td></td>
<td>#3</td>
<td>6-10</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS</td>
<td>9-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>9-0</td>
</tr>
<tr>
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<td>#2</td>
<td>8-7</td>
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<td>Southern Pine</td>
<td>SS</td>
<td>9-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
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<td></td>
<td></td>
<td>#2</td>
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<td>#3</td>
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<tr>
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<td>Spruce-Pine-Fir</td>
<td>SS</td>
<td>9-0</td>
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<tr>
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<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#3</td>
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</tr>
<tr>
<td>24</td>
<td>Douglas Fir-Larch</td>
<td>SS</td>
<td>9-0</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>8-8</td>
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<td>#3</td>
<td>6-2</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>8-4</td>
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<tr>
<td></td>
<td></td>
<td>#2</td>
<td>7-11</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#3</td>
<td>6-2</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS</td>
<td>8-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#2</td>
<td>7-7</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#3</td>
<td>5-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS</td>
<td>8-4</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>8-1</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#2</td>
<td>8-1</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#3</td>
<td>6-2</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

Check sources for availability of timber in lengths greater than 20 feet.

a. End bearing length shall be increased to 2 inches.
24.8.4.2.2 Bearing.
The ends of each joist shall have not less than 38 mm (1 1/2 inches) of bearing on wood or metal, or not less than 76 mm (3 inches) on masonry, except where supported on a 25 mm by 102 mm (1-inch by 4-inch) ribbon strip and nailed to the adjoining stud.

24.8.4.2.3 Framing details.
Joists shall be supported laterally at the ends and at each support by solid blocking except where the ends of the joists are nailed to a header, band or rim joist or to an adjoining stud or by other means. Solid blocking shall be not less than 51 mm (2 inches) in thickness and the full depth of the joist. Joist framing from opposite sides of a beam, girder or partition shall be lapped not less than 76 mm (3 inches) or the opposing joists shall be tied together in an approved manner. Joists framing into the side of a wood girder shall be supported by framing anchors or on ledger strips not less than 51 mm by 51 mm (2 inches by 2 inches).

24.8.4.2.4 Notches and holes.
Notches on the ends of joists shall not exceed one-fourth the joist depth. Notches in the top or bottom of joists shall not exceed one-sixth the depth and shall not be located in the middle third of the span. Holes bored in joists shall not be within 2 inches (51 mm) of the top or bottom of the joist and the diameter of any such hole shall not exceed one-third the depth of the joist.

24.8.4.3 Engineered wood products.
Engineered wood products shall be installed in accordance with manufacturer’s recommendations. Cuts, notches and holes bored in trusses, structural composite timber, structural glued-laminated members or I-joists are not permitted except where permitted by the manufacturer’s recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

24.8.4.4 Framing around openings.
Trimmer and header joists shall be doubled, or of timber of equivalent cross clause, where the span of the header exceeds 1219 mm (4 feet). The ends of header joists more than 1829 mm (6 feet) in length shall be supported by framing anchors or joist hangers unless bearing on a beam, partition or wall. Tail joists over 3658 mm (12 feet) in length shall be supported at the header by framing anchors or on ledger strips not less than 51 mm by 51 mm (2 inches by 2 inches).

24.8.4.4.1 Openings in floor diaphragms in Seismic Design Categories B, C, D and E.
Openings in horizontal diaphragms in Seismic Design Categories B, C, D and E with a dimension that is greater than 1219 mm (4 feet) shall be constructed with metal ties and blocking in accordance with this clause and Figure 24.8.4.4.1(1). Metal ties shall be not less than 0.058 inch [1.47 mm (16 galvanized gage)] in thickness by 38 mm (1 1/2 inches) in width and shall have a yield stress not less than 227 Mpa (33,000 psi). Blocking shall extend not less than the dimension of the opening in the direction of the tie and blocking. Ties shall be attached to blocking in accordance with the manufacturer’s instructions but with not less than eight 16d common nails on each side of the header-joist interclause.

Openings in floor diaphragms in Seismic Design Categories D and E shall not have any dimension exceeding 50 percent of the distance between braced wall lines or an area greater than 25 percent of the area between orthogonal pairs of braced wall lines [see Figure 2308.4.4.1(2)]; or the portion of the structure containing the opening shall be designed in accordance with accepted engineering practice to resist the forces specified in Part 17, to the extent such irregular opening affects the performance of the conventional framing system.
24.8.4.4.2 Vertical offsets in floor diaphragms in Seismic Design Categories D and E.

In Seismic Design Categories D and E, portions of a floor level shall not be vertically offset such that the framing members on either side of the offset cannot be lapped or tied together in an approved manner in accordance with Figure 24.8.4.4.2 unless the portion of the structure containing the irregular offset is designed in accordance with accepted engineering practice.
Exception: Framing supported directly by foundations need not be lapped or tied directly together.

24.8.4.5 Joists supporting bearing partitions.
Bearing partitions parallel to joists shall be supported on beams, girders, doubled joists, walls or other bearing partitions. Bearing partitions perpendicular to joists shall not be offset from supporting girders, walls or partitions more than the joist depth unless such joists are of sufficient size to carry the additional load.

24.8.4.6 Lateral support.
Floor and ceiling framing with a nominal depth-to-thickness ratio not less than 5 to 1 shall have one edge held in line for the entire span. Where the nominal depth-to-thickness ratio of the framing member exceeds 6 to 1, there shall be one line of bridging for each 2438 mm (8 feet) of span, unless both edges of the member are held in line. The bridging shall consist of not less than 25 mm by 76 mm (1-inch by 3-inch) timber, double nailed at each end, or equivalent metal bracing of equal rigidity, full-depth solid blocking or other approved means. A line of bridging shall be required at supports where equivalent lateral support is not otherwise provided.

24.8.4.7 Structural floor sheathing.
Structural floor sheathing shall comply with the provisions of Clause 24.4.8.1.

24.8.4.8 Under-floor ventilation.
For under-floor ventilation, see part 13

24.8.4.9 Floor framing supporting braced wall panels.
Where braced wall panels are supported by cantilevered floors or are set back from the floor joist support, the floor framing shall comply with Clause 24.8.6.7.

24.8.4.10 Anchorage of exterior means of escape components in Seismic Design Categories D and E.
Exterior escape balconies, exterior stairways and ramps and similar means of escape components in structures assigned to Seismic Design Category D or E shall be positively anchored to the primary structure at not more than 2438 mm (8 feet) on center or shall be designed for lateral forces. Such attachment shall not be accomplished by use of toenails or nails subject to withdrawal.

24.8.5 Wall construction.
Walls of conventional light-frame construction shall be in accordance with this clause.

24.8.5.1 Stud size, height and spacing.
The size, height and spacing of studs shall be in accordance with Table 24.8.5.1.

Studs shall be continuous from a support at the sole plate to a support at the top plate to resist loads perpendicular to the wall. The support
shall be a foundation or floor, ceiling or roof diaphragm or shall be designed in accordance with accepted engineering practice.

### TABLE 2308.5.1 SIZE, HEIGHT AND SPACING OF WOOD STUDS

<table>
<thead>
<tr>
<th>STUD SIZE (inches)</th>
<th>BEARING WALLS</th>
<th>NONBEARING WALLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LATERALLY UNSUPPORTED STUD HEIGHT</td>
<td>SUPPORTING ROOF AND CEILING ONLY</td>
</tr>
<tr>
<td></td>
<td>(feet)</td>
<td></td>
</tr>
<tr>
<td>2 x 3 b</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 x 4</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>3 x 4</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>2 x 5</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>2 x 6</td>
<td>10</td>
<td>24</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

- a. Listed heights are distances between points of lateral support placed perpendicular to the plane of the wall. Increases in unsupported height are permitted where justified by an analysis.
- b. Shall not be used in exterior walls.
- c. Utility-grade studs shall not be spaced more than 16 inches on center or support more than a roof and ceiling, or exceed 8 feet in height for exterior walls and load-bearing walls or 10 feet for interior nonload-bearing walls.

**Exception:** Jack studs, trimmer studs and cripple studs at openings in walls that comply with Table 24.8.4.1.1(1) or 24.8.4.1.1(2).

### 24.8.5.2 Framing details.

Studs shall be placed with their wide dimension perpendicular to the wall. Not less than three studs shall be installed at each corner of an exterior wall.

**Exceptions:**

1. In interior nonbearing walls and partitions, studs are permitted to be set with the long dimension parallel to the wall.

2. At corners, two studs are permitted, provided that wood spacers or backup cleats of 9.5 mm (3/8-inch-thick) wood structural panel, 9.5 mm (3/8-inch) Type M "Interior Glue" particleboard, 25 mm (1-inch-thick) timber or other approved devices that will serve as an adequate backing for the attachment of facing materials are used. Where fire-resistance ratings or shear values are involved, wood spacers, backup cleats or other devices shall not be used unless specifically approved for such use.

### 24.8.5.3 Plates and sills.

Studs shall have plates and sills in accordance with this clause.

#### 24.8.5.3.1 Bottom plate or sill.

Studs shall have full bearing on a plate or sill. Plates or sills shall be not less than 51 mm (2
inches) nominal in thickness and have a width not less than the width of the wall studs.

**24.8.5.3.2 Top plates.**

Bearing and exterior wall studs shall be capped with double top plates installed to provide overlapping at corners and at interclauses with other partitions. End joints in double top plates shall be offset not less than 1219 mm (48 inches), and shall be nailed in accordance with Table 24.4.10.1. Plates shall be a nominal 2 inches (51 mm) in depth and have a width not less than the width of the studs.

**Exception:** A single top plate is permitted, provided that the plate is adequately tied at corners and intersecting walls by not less than the equivalent of 76 mm by 152 mm (3-inch by 6-inch) by 0.914 mm (0.036-inch-thick) galvanized steel plate that is nailed to each wall or segment of wall by six 8d [2 1/2" × 0.113" (64-mm by 2.87 mm)] box nails or equivalent on each side of the joint. For the butt-joint splice between adjacent single top plates, not less than the equivalent of a 76 mm by 304 mm (3-inch by 12-inch) by 0.914 mm-thick (0.036-inch) galvanized steel plate that is nailed to each wall or segment of wall by 12 8d [2 1/2" × 0.113-inch (64 mm by 2.87 mm)] box nails on each side of the joint shall be required, provided that the rafters, joists or trusses are centered over the studs with a tolerance of not more than 25 mm (1 inch). The top plate shall not be required over headers that are in the same plane and in line with the upper surface of the adjacent top plates and are tied to adjacent wall clauses as required for the butt joint splice between adjacent single top plates.

Where bearing studs are spaced at 610 mm (24-inch) intervals, top plates are less than two 2-inch by 6-inch (51 mm by 152 mm) or two 3-inch by 4-inch (76 mm by 102 mm) members and the floor joists, floor trusses or roof trusses that they support are spaced at more than 16-inch (406 mm) intervals, such joists or trusses shall bear within 5 inches (127 mm) of the studs beneath or a third plate shall be installed.

**24.8.5.4 Nonload-bearing walls and partitions.**

In nonload-bearing walls and partitions, that are not part of a braced wall panel, studs shall be spaced not more than 610 mm (24 inches) on center. In interior nonload-bearing walls and partitions, studs are permitted to be set with the long dimension parallel to the wall. Where studs are set with the long dimensions parallel to the wall, use of utility grade timber or studs exceeding 3048 mm (10 feet) is not permitted. Interior nonload-bearing partitions shall be capped with not less than a single top plate installed to provide overlapping at corners and at interclauses with other walls and partitions. The plate shall be continuously tied at joints by solid blocking not less than 406 mm (16 inches) in length and equal in size to the plate or by 12.7 mm by 38 mm (1/2-inch by 1 1/2-inch) metal ties with spliced clauses fastened with two 16d nails on each side of the joint.

**24.8.5.5 Openings in walls and partitions.**

Openings in exterior and interior walls and partitions shall comply with Clauses 24.8.5.5.1 through 24.8.5.5.3.

**24.8.5.5.1 Openings in exterior bearing walls.**

Headers shall be provided over each opening in exterior bearing walls. The size and spans in Table 24.8.4.1.1(1) are permitted to be used for one- and two-family dwellings. Headers for other buildings shall be designed in accordance with Clause 24.1.2, Item 1 or 2. Headers of two or more pieces of nominal 51 mm (2-inch) framing timber set on edge shall be permitted in accordance with Table 24.8.4.1.1(1) and nailed together in accordance with Table 24.4.10.1 or of solid timber of equivalent size. Single-member headers of nominal 51 mm (2-inch) thickness shall be framed with a single flat 2-inch-nominal (51 mm) member or wall plate not less in width than the wall studs on the top and bottom of the header in accordance with Figures 24.8.5.5.1(1) and 24.8.5.5.1(2) and face nailed to the top and bottom of the header with 10d box nails [3 inches × 0.128 inches (76 mm × 3.3 mm)] spaced 305 mm (12 inches) on center.
Wall studs shall support the ends of the header in accordance with Table 24.8.4.1.1(1). Each end of a lintel or header shall have a bearing length of not less than 38 mm ($1 \frac{1}{2}$ inches) for the full width of the lintel.

24.8.5.5.2 Openings in interior bearing partitions.

Headers shall be provided over each opening in interior bearing partitions as required in Clause 24.8.5.5.1. The spans in Table 24.8.4.1.1(2) are permitted to be used. Wall studs shall support the ends of the header in accordance with Table 24.8.4.1.1(1) or 24.8.4.1.1(2), as applicable.

24.8.5.5.3 Openings in interior nonbearing partitions.

Openings in nonbearing partitions are permitted to be framed with single studs and headers. Each end of a lintel or header shall have a bearing length of not less than 38 mm ($1 \frac{1}{2}$ inches) for the full width of the lintel.

24.8.5.6 Cripple walls.

Foundation cripple walls shall be framed of studs that are not less than the size of the studding above and not less than 356 mm (14 inches) in length, or shall be framed of solid blocking. Where exceeding 1219 mm (4 feet) in height, such walls shall be framed of studs having the size required for an additional storey. See Clause 24.8.6.6 for cripple wall bracing.

24.8.5.7 Bridging.

Unless covered by interior or exterior wall coverings or sheathing meeting the minimum requirements of this Code, stud partitions or walls with studs having a height-to-least-thickness ratio exceeding 50 shall have bridging that is not less than 51 mm (2 inches) in thickness and of the same width as the studs fitted snugly and nailed thereto to provide adequate lateral support. Bridging shall be placed in every stud cavity and at a frequency such that studs so braced shall not have a height-to-least-thickness ratio exceeding 50 with the height of the stud measured between horizontal framing and bridging or between bridging, whichever is greater.
24.8.5.8 Pipes in walls.
Stud partitions containing plumbing, heating or other pipes shall be framed and the joists underneath spaced to provide proper clearance for the piping. Where a partition containing piping runs parallel to the floor joists, the joists underneath such partitions shall be doubled and spaced to permit the passage of pipes and shall be bridged. Where plumbing, heating or other pipes are placed in, or partly in, a partition, necessitating the cutting of the soles or plates, a metal tie not less than 1.47 mm (0.058 inch) (16 ga. galvanized gage) and 38 mm (1/2 inches) in width shall be fastened to each plate across and to each side of the opening with not less than six 16d nails.

24.8.5.9 Cutting and notching.
In exterior walls and bearing partitions, wood studs are permitted to be cut or notched to a depth not exceeding 25 percent of the width of the stud. Cutting or notching of studs to a depth not greater than 40 percent of the width of the stud is permitted in nonbearing partitions not supporting loads other than the weight of the partition.

24.8.5.10 Bored holes.
Bored holes not greater than 40 percent of the stud width are permitted to be bored in any wood stud. Bored holes not greater than 60 percent of the stud width are permitted in nonbearing partitions or in any wall where each bored stud is doubled, provided that not more than two such successive doubled studs are so bored. The edge of a bored hole shall not be nearer than 15.9 mm (5/8 inch) to the edge of the stud. Bored holes shall not be located at the same clause of stud as a cut or notch.

24.8.5.11 Exterior wall sheathing.
Except where stucco construction that complies with Clause 26.10 is installed, the outside of exterior walls, including gables, of enclosed buildings shall be sheathed with one of the materials of the nominal thickness specified in Table 24.8.5.11 with fasteners in accordance with the requirements of Clause 24.4.10 or fasteners designed in accordance with accepted engineering practice. Alternatively, sheathing materials and fasteners complying with Clause 24.4.6 shall be permitted.

<table>
<thead>
<tr>
<th>SHEATHING TYPE</th>
<th>MINIMUM THICKNESS</th>
<th>MAXIMUM WALL STUD SPACING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagonal wood boards</td>
<td>5/8 inch</td>
<td>24 inches on center</td>
</tr>
<tr>
<td>Structural fibreboard</td>
<td>1/2 inch</td>
<td>16 inches on center</td>
</tr>
<tr>
<td>Wood structural panel</td>
<td>In accordance with Tables 24.8.6.3(2) and 2308.6.3(3)</td>
<td>—</td>
</tr>
<tr>
<td>M-S “Exterior Glue” and M-2 “Exterior Glue” particleboard</td>
<td>In accordance with Clause 24.6.3 and Table 24.8.6.3(4)</td>
<td>—</td>
</tr>
<tr>
<td>Gypsum sheathing</td>
<td>1/2 inch</td>
<td>16 inches on center</td>
</tr>
<tr>
<td>Reinforced cement mortar</td>
<td>1 inch</td>
<td>24 inches on center</td>
</tr>
<tr>
<td>Hardboard panel siding</td>
<td>In accordance with Table 24.8.6.3(5)</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm.

24.8.6 Wall bracing.
Buildings shall be provided with exterior and interior braced wall lines as described in Clauses 24.8.6.1 through 24.8.6.10.2.

24.8.6.1 Braced wall lines.
For the purpose of determining the amount and location of bracing required along each storey level of a building, braced wall lines shall be designated as straight lines through the building plan in both the longitudinal and transverse
direction and placed in accordance with Table 24.8.6.1 and Figure 24.8.6.1. Braced wall line spacing shall not exceed the distance specified in Table 24.8.6.1. In structures assigned to Seismic Design Category D or E, braced wall lines shall intersect perpendicularly to each other.
For SI: 1 foot = 304.8 mm.

### FIGURE 24.8.6.1 BASIC COMPONENTS OF THE LATERAL BRACING SYSTEM

**TABLE 24.8.6.1** WALL BRACING REQUIREMENTS

<table>
<thead>
<tr>
<th>SEISMIC DESIGN CATEGORY</th>
<th>STORY CONDITION (SEE SECTION 2918.2)</th>
<th>MAXIMUM SPACING OF BRACED WALL LINES</th>
<th>BRACED PANEL LOCATION, SPACING (O.C.) AND MINIMUM PERCENTAGE (X)</th>
<th>MAXIMUM DISTANCE OF BRACED WALL PANELS FROM EACH END OF BRACED WALL LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>35° - 0° Each end and ≤ 25° - 0° o.c.</td>
<td>Each end and ≤ 25° - 0° o.c.</td>
<td>12° - 6°</td>
</tr>
<tr>
<td>A and B</td>
<td></td>
<td>35° - 0° Each end and ≤ 25° - 0° o.c.</td>
<td>Each end and ≤ 25° - 0° o.c.</td>
<td>12° - 6°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35° - 0° NP</td>
<td>Each end and ≤ 25° - 0° o.c.</td>
<td>12° - 6°</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>35° - 0° NP</td>
<td>Each end and ≤ 25° - 0° o.c. (minimum 25% of wall length)²</td>
<td>12° - 6°</td>
</tr>
<tr>
<td>D and E</td>
<td>25° - 0° NP</td>
<td>$S_{25} &lt; 0.50$: Each end and ≤ 25° - 0° o.c. (minimum 21% of wall length)³</td>
<td>$S_{25} &lt; 0.50$: Each end and ≤ 25° - 0° o.c. (minimum 43% of wall length)³</td>
<td>8° - 0°</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
24.8.6.2 Braced wall panels.

Braced wall panels shall be placed along braced wall lines in accordance with Table 2308.6.1 and Figure 2308.6.1 and as specified in Table 24.8.6.3(1). A braced wall panel shall be located at each end of the braced wall line and at the corners of intersecting braced wall lines or shall begin within the maximum distance from the end of the braced wall line in accordance with Table 24.8.6.1. Braced wall panels in a braced wall line shall not be offset from each other by more than 1219 mm (4 feet). Braced wall panels shall be clearly indicated on the plans.

24.8.6.3 Braced wall panel methods.

Construction of braced wall panels shall be by one or a combination of the methods in Table 24.8.6.3(1). Braced wall panel length shall be in accordance with Clause 24.8.6.4 or 24.8.6.5.

<table>
<thead>
<tr>
<th>METHODS, MATERIAL</th>
<th>MINIMUM THICKNESS</th>
<th>FIGURE</th>
<th>CONNECTION CRITERIA*</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIB* Let-in-bracing</td>
<td>1&quot; × 4&quot; wood or approved metal straps attached at 45º to 60º angles to studs at maximum of 16&quot; o.c.</td>
<td><img src="image" alt="Figure" /></td>
<td>Table 2304.10.1</td>
</tr>
<tr>
<td>DWB Diagonal wood boards</td>
<td>3/4&quot; thick (1&quot; nominal) × 6&quot; minimum width to studs at maximum of 24&quot; o.c.</td>
<td><img src="image" alt="Figure" /></td>
<td>Table 2304.10.1</td>
</tr>
<tr>
<td>WSP Wood structural panel</td>
<td>5/8&quot;, in accordance with Table 2308.6.3(2) or 2308.6.3(3)</td>
<td><img src="image" alt="Figure" /></td>
<td>Table 2304.10.1</td>
</tr>
<tr>
<td>SFB Structural fiberboard sheathing</td>
<td>3/8&quot;, in accordance with Table 2304.10.1 to studs at maximum 16&quot; o.c.</td>
<td><img src="image" alt="Figure" /></td>
<td>Table 2304.10.1</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>METHODS, MATERIAL</th>
<th>MINIMUM THICKNESS</th>
<th>FIGURE</th>
<th>CONNECTION CRITERIA*</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB Gypsum board (Double sided)</td>
<td>$\frac{1}{4}''$ or $\frac{1}{2}''$ by not less than 4' wide to studs at maximum of 24'' o.c.</td>
<td><img src="image1.png" alt="Figure" /></td>
<td>Section 2506.2 for exterior and interior sheathing: 5d annular ringed common nails (Type B or 0.080&quot;) or 1(\frac{1}{4})&quot; screws (Type W or S) for $\frac{1}{4}''$ gypsum board or $\frac{1}{2}''$ screws (Type W or S) for $\frac{3}{8}''$ gypsum board. For all braced wall panel locations: 7&quot; o.c. along panel edges (excluding top and bottom plates) and 7&quot; o.c. in the field.</td>
</tr>
<tr>
<td>PBS Particleboard sheathing</td>
<td>$\frac{1}{2}''$ or $\frac{3}{4}''$ in accordance with Table 2308.6.3(4) to studs at maximum of 16&quot; o.c.</td>
<td><img src="image2.png" alt="Figure" /></td>
<td>6d common (2&quot; long x 0.113&quot; dia.) nails for $\frac{1}{2}''$ thick sheathing or 8d common (2(\frac{1}{4})&quot; long x 0.131&quot; dia.) nails for $\frac{3}{4}''$ thick sheathing. 3&quot; edges 6&quot; field</td>
</tr>
<tr>
<td>PCP Portland cement plaster</td>
<td>Section 2510 to studs at maximum of 16&quot; o.c.</td>
<td><img src="image3.png" alt="Figure" /></td>
<td>1(\frac{1}{2})&quot;long, 11 gage, $\frac{7}{64}''$ dia. head nails or $\frac{5}{16}''$ long, 16 gage staples. 6&quot; o.c. on all framing members</td>
</tr>
<tr>
<td>HPS Hardboard panel siding</td>
<td>$\frac{3}{8}''$ in accordance with Table 2308.6.3(5)</td>
<td><img src="image4.png" alt="Figure" /></td>
<td>Table 2304.10.1. 4&quot; edges 8&quot; field</td>
</tr>
<tr>
<td>ABW Alternate braced wall</td>
<td>$\frac{3}{8}''$</td>
<td><img src="image5.png" alt="Figure" /></td>
<td>Figure 2308.6.5.1 and Section 2308.6.5.1. Figure 2308.6.5.1</td>
</tr>
<tr>
<td>PFH Portal frame with hold-downs</td>
<td>$\frac{7}{16}''$</td>
<td><img src="image6.png" alt="Figure" /></td>
<td>Figure 2308.6.5.2 and Section 2308.6.5.2. Figure 2308.6.3.2</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 degree = 0.01745 rad.

a. Method LIB shall have gypsum board fastened to one or more side(s) with nails or screws.
### TABLE 24.8.6.3(2) EXPOSED PLYWOOD PANEL SIDING

<table>
<thead>
<tr>
<th>MINIMUM THICKNESS (inch)</th>
<th>MINIMUM NUMBER OF PLIES</th>
<th>STUD SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8</td>
<td>3</td>
<td>b 16</td>
</tr>
<tr>
<td>1/2</td>
<td>4</td>
<td>24</td>
</tr>
</tbody>
</table>

**Note:**
For SI: 1 inch = 25.4 mm.

a. Thickness of grooved panels is measured at bottom of grooves.
b. Spans are permitted to be 24 inches if plywood siding applied with face grain perpendicular to studs or over one of the following: 1-inch board sheathing; 7/16-inch wood structural panel sheathing; or 3/8-inch wood structural panel sheathing with strength axis (which is the long direction of the panel unless otherwise marked) of sheathing perpendicular to studs.

### TABLE 24.8.6.3(3) WOOD STRUCTURAL PANEL WALL SHEATHING

(Not exposed to the weather, strength axis parallel or perpendicular to studs except as indicated)

<table>
<thead>
<tr>
<th>MINIMUM THICKNESS (inch)</th>
<th>PANEL SPAN RATING</th>
<th>STUD SPACING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Siding nailed to studs</td>
</tr>
<tr>
<td>3/8, 15/32, 1/2</td>
<td>16/0, 20/0, 24/0, 32/16 Wall—24” o.c.</td>
<td>24</td>
</tr>
<tr>
<td>7/16, 15/32, 1/2</td>
<td>24/0, 24/16, 32/16 Wall—24” o.c.</td>
<td>24</td>
</tr>
</tbody>
</table>

**Note:**
For SI: 1 inch = 25.4 mm.

a. Plywood shall consist of four or more plies.
b. Blocking of horizontal joints shall not be required except as specified in Clause 24.8.6.4.
### TABLE 2308.6.3(4) ALLOWABLE SPANS FOR PARTICLEBOARD WALL SHEATHING
(Not exposed to the weather, long dimension of the panel parallel or perpendicular to studs)

<table>
<thead>
<tr>
<th>GRADE</th>
<th>THICKNESS (inch)</th>
<th>STUD SPACING (inches)</th>
<th>Sheathing under coverings specified in Clause 24.8.6.3 parallel or perpendicular to studs</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-S “Exterior Glue” and M-2 “Exterior Glue”</td>
<td>3/8</td>
<td>16</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1/2</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm.

### TABLE 24.8.6.3(5) HARDBOARD SIDING

<table>
<thead>
<tr>
<th>SIDING</th>
<th>MINIMUM NOMINAL THICKNESS (inch)</th>
<th>2 x 4 FRAMING MAXIMUM SPACING</th>
<th>NAIL SIZE</th>
<th>NAIL SPACING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>General</td>
<td>Bracing panels</td>
</tr>
<tr>
<td>1. Lap siding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct to studs</td>
<td>3/8</td>
<td>16” o.c.</td>
<td>8d</td>
<td>16” o.c.</td>
</tr>
<tr>
<td>Over sheathing</td>
<td>3/8</td>
<td>16” o.c.</td>
<td>10d</td>
<td>16” o.c.</td>
</tr>
<tr>
<td>2. Square edge panel siding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct to studs</td>
<td>3/8</td>
<td>24” o.c.</td>
<td>6d</td>
<td>6” o.c. edges; 12” o.c. at intermediate supports</td>
</tr>
<tr>
<td>Over sheathing</td>
<td>3/8</td>
<td>24” o.c.</td>
<td>8d</td>
<td>6” o.c. edges; 12” o.c. at intermediate supports</td>
</tr>
<tr>
<td>3. Shiplap edge panel siding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct to studs</td>
<td>3/8</td>
<td>16” o.c.</td>
<td>6d</td>
<td>6” o.c. edges; 12” o.c. at intermediate supports</td>
</tr>
<tr>
<td>Over sheathing</td>
<td>3/8</td>
<td>16” o.c.</td>
<td>8d</td>
<td>6” o.c. edges; 12” o.c. at intermediate supports</td>
</tr>
</tbody>
</table>

**Note:** For SI: 1 inch = 25.4 mm.

- Nails shall be corrosion resistant.
- Minimum acceptable nail dimensions:
- Where used to comply with Clause 24.8.6.
| Shank diameter | Panel Siding (inch) | 0.092 |
| Head diameter  | Lap Siding (inch)   | 0.099 |

- **d.** Nail length must accommodate the sheathing and penetrate framing $\frac{1}{2}$ inches.

### 24.8.6.4 Braced wall panel construction.

For Methods DWB, WSP, SFB, PBS, PCP and HPS, each panel must be not less than 1219 mm (48 inches) in length, covering three stud spaces where studs are spaced 406 mm (16 inches) on center and covering two stud spaces where studs are spaced 24 inches (610 mm) on center. Braced wall panels less than 1219 mm (48 inches) in length shall not contribute toward the amount of required bracing. Braced wall panels that are longer than the required length shall be credited for their actual length. For Method GB, each panel must be not less than 2438 mm (96 inches) in length where applied to one side of the studs or 1219 mm (48 inches) in length where applied to both sides.

Vertical joints of panel sheathing shall occur over studs and adjacent panel joints shall be nailed to common framing members. Horizontal joints shall occur over blocking or other framing equal in size to the studding except where waived by the installation requirements for the specific sheathing materials. Sole plates shall be nailed to the floor framing in accordance with Clause 24.8.6.7 and top plates shall be connected to the framing above in accordance with Clause 24.8.6.7.2. Where joists are perpendicular to braced wall lines above, blocking shall be provided under and in line with the braced wall panels.

### 24.8.6.5 Alternative bracing.

An alternate braced wall (ABW) or a portal frame with hold-downs (PFH) de-scribed in this clause is permitted to substitute for a 1219 mm (48-inch) braced wall panel of Method DWB, WSP, SFB, PBS, PCP or HPS. For Method GB, each 96-inch (2438 mm) clause (applied to one face) or 1219 mm (48-inch) clause (applied to both faces) or portion thereof required by Table 24.8.6.1 is permitted to be replaced by one panel constructed in accordance with Method ABW or PFH.

#### 24.8.6.5.1. Alternate braced wall (ABW).

An ABW shall be constructed in accordance with this clause and Figure 24.8.6.5.1. In one-storey buildings, each panel shall have a length of not less than 2 feet 8 inches (813 mm) and a height of not more than 3048 mm (10 feet). Each panel shall be sheathed on one face with 3.2 mm ($\frac{3}{8}$-inch) minimum-thickness wood structural panel sheathing nailed with 8d common or galvanized box nails in accordance with Table 24.4.10.1 and blocked at wood structural panel edges. Two anchor bolts installed in accordance with Clause 24.8.3.1 shall be provided in each panel. Anchor bolts shall be placed at each panel outside quarter points. Each panel end stud shall have a hold-down device fastened to the foundation, capable of providing an approved uplift capacity of not less than 8006 N (1,800 pounds). The hold-down device shall be installed in accordance with the manufacturer’s recommendations. The ABW shall be supported directly on a foundation or on floor framing supported directly on a foundation that is continuous across the entire length of the braced wall line. This foundation shall be reinforced with not less than one No. 4 bar top and bottom. Where the continuous foundation is required to have a depth greater than 305 mm (12 inches), a minimum 305 mm by 305 mm (12-inch by 12-inch) continuous footing or turned-down slab edge is permitted at door openings in the braced wall line. This continuous footing or turned-down slab edge shall be reinforced with not less than one No. 4 bar top and bottom. This reinforcement shall be lapped 381 mm (15 inches) with the reinforcement required in the
A continuous foundation located directly under the braced wall line.

Where the ABW is installed at the first storey of two-storey buildings, the wood structural panel sheathing shall be provided on both faces, three anchor bolts shall be placed at one-quarter points and tie-down device uplift capacity shall be not less than 13,344 N (3,000 pounds).

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

FIGURE 24.8.6.5.1 ALTERNATE BRACED WALL PANEL (ABW)
Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.448 N.

**FIGURE 24.8.6.5.2 PORTAL FRAME WITH HOLD-DOWNS (PFH)**

24.8.6.5.2 Portal frame with hold-downs (PFH).

A PFH shall be constructed in accordance with this clause and Figure 24.8.6.5.2. The adjacent door or window opening shall have a full-length header.

In one-storey buildings, each panel shall have a length of not less than 16 inches (406 mm) and a height of not more than 3048 mm (10 feet). Each panel shall be sheathed on one face with a single layer of 9.5 mm (3/8-inch) minimum-thickness wood structural panel sheathing nailed with 8d common or galvanized box nails in accordance with Figure 24.8.6.5.2. The wood structural panel sheathing shall extend up over the solid sawn or glued-laminated header and shall be nailed in accordance with Figure 24.8.6.5.2. A built-up header consisting of not fewer than two 2-inch by 12-inch (51 mm by 305 mm) boards, fastened in accordance with Item 24 of Table 2304.10.1 shall be permitted to be used. A spacer, if used, shall be placed on the side of the built-up beam opposite the wood structural panel sheathing. The header shall extend between the inside faces of the first full-length outer studs of each panel. The clear span of the header between the inner studs of each panel shall be not less than 1829 mm (6 feet) and not more than 5486 mm (18 feet) in length. A strap with an uplift capacity of not less than 4,400 N (1,000 pounds) shall fasten the header to the inner studs opposite the sheathing. One
anchor bolt not less than 15.9 mm (\(\frac{5}{8}\) inch) diameter and installed in accordance with Clause 24.8.3.1 shall be provided in the center of each sill plate. The studs at each end of the panel shall have a hold-down device fastened to the foundation with an uplift capacity of not less than 15 570 N (3,500 pounds).

Where a panel is located on one side of the opening, the header shall extend between the inside face of the first full-length stud of the panel and the bearing studs at the other end of the opening. A strap with an uplift capacity of not less than 4400 N (1,000 pounds) shall fasten the header to the bearing studs. The bearing studs shall have a hold-down device fastened to the foundation with an uplift capacity of not less than 4400 N (1,000 pounds). The hold-down devices shall be an embedded strap type, installed in accordance with the manufacturer’s recommendations. The PFH panels shall be supported directly on a foundation that is continuous across the entire length of the braced wall line. This foundation shall be reinforced with not less than one No. 4 bar top and bottom. Where the continuous foundation is required to have a depth greater than 305 mm (12 inches), a minimum 305 mm by 305 mm (12-inch by 12-inch) continuous footing or turned-down slab edge is permitted at door openings in the braced wall line. This continuous footing or turned-down slab edge shall be reinforced with not less than one No. 4 bar top and bottom. This reinforcement shall be lapped not less than 381 mm (15 inches) with the reinforcement required in the continuous foundation located directly under the braced wall line.

Where a PFH is installed at the first storey of two-storey buildings, each panel shall have a length of not less than 610 mm (24 inches).

24.8.6.6 Cripple wall bracing.
Cripple walls shall be braced in accordance with Clause 24.8.6.6.1 or 24.8.6.6.2.

24.8.6.6.1 Cripple wall bracing in Seismic Design Categories A, B and C.
For the purposes of this clause, cripple walls in Seismic Design Categories A, B and C having a stud height exceeding 356 mm (14 inches) shall be considered to be a storey and shall be braced in accordance with Table 24.8.6.1. Spacing of edge nailing for required cripple wall bracing shall not exceed 152 mm (6 inches) on center along the foundation plate and the top plate of the cripple wall. Nail size, nail spacing for field nailing and more restrictive boundary nailing requirements shall be as required elsewhere in the Code for the specific bracing material used.

24.8.6.6.2 Cripple wall bracing in Seismic Design Categories D and E.
For the purposes of this clause, cripple walls in Seismic Design Categories D and E having a stud height exceeding 356 mm (14 inches) shall be considered to be a storey and shall be braced in accordance with Table 24.8.6.1. Where interior braced wall lines occur without a continuous foundation below, the length of parallel exterior cripple wall bracing shall be one and one-half times the lengths required by Table 24.8.6.1. Where the cripple wall sheathing type used is Method WSP or DWB and this additional length of bracing cannot be provided, the capacity of WSP or DWB sheathing shall be increased by reducing the spacing of fasteners along the perimeter of each piece of sheathing to 102 mm (4 inches) on center.

24.8.6.7 Connections of braced wall panels.
Braced wall panel joints shall occur over studs or blocking. Braced wall panels shall be fastened to studs, top and bottom plates and at panel edges. Braced wall panels shall be applied to nominal 2-inch-wide [actual 1\(\frac{1}{2}\)-inch (38 mm)] or larger stud framing.

24.8.6.7.1 Bottom plate connection.
Braced wall line bottom plates shall be connected to joists or full-depth blocking below in accordance with Table 24.4.10.1, or to foundations in accordance with Clause 24.8.6.7.3.
### TABLE 24.8.7.1(1) CEILING JOIST SPANS FOR COMMON TIMBER SPECIES
(Uninhabitable attics without storage, live load = 10 psf, L/ = 240)

<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (INCHES)</th>
<th>SPECIES AND GRADE</th>
<th>2 x 4 (ft. - in.)</th>
<th>2 x 6 (ft. - in.)</th>
<th>2 x 8 (ft. - in.)</th>
<th>2 x 10 (ft. - in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
<td>13-2</td>
<td>20-8</td>
<td>Note a</td>
<td>Note a</td>
</tr>
<tr>
<td>Douglas Fir-Larch</td>
<td>#1</td>
<td>12-8</td>
<td>19-11</td>
<td>Note a</td>
<td>Note a</td>
</tr>
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<td>#2</td>
<td>12-5</td>
<td>19-6</td>
<td>25-8</td>
<td>Note a</td>
</tr>
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<td>Douglas Fir-Larch</td>
<td>#3</td>
<td>10-10</td>
<td>15-10</td>
<td>20-1</td>
<td>24-6</td>
</tr>
<tr>
<td>Hem-Fir</td>
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<td>12-5</td>
<td>19-6</td>
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<td>Note a</td>
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<td>19-1</td>
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<td>Note a</td>
</tr>
<tr>
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<td>18-2</td>
<td>24-0</td>
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<td>#3</td>
<td>10-10</td>
<td>14-11</td>
<td>18-9</td>
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<td>19-1</td>
<td>25-2</td>
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<td>15-10</td>
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<td>24-6</td>
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<td>11-11</td>
<td>18-9</td>
<td>24-8</td>
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<td>23-10</td>
<td>Note a</td>
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<td>17-8</td>
<td>23-0</td>
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<td>11-0</td>
<td>17-4</td>
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<td>Note a</td>
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<tr>
<td>Hem-Fir</td>
<td>#2</td>
<td>10-6</td>
<td>16-6</td>
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<tr>
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<td>9-5</td>
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<td>11-3</td>
<td>17-8</td>
<td>23-4</td>
<td>Note a</td>
</tr>
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<td>16-11</td>
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<td>8-9</td>
<td>12-11</td>
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<td>19-9</td>
</tr>
<tr>
<td>Spruce-Pine-Fir</td>
<td>SS</td>
<td>11-0</td>
<td>17-4</td>
<td>22-10</td>
<td>Note a</td>
</tr>
<tr>
<td>Spruce-Pine-Fir</td>
<td>#1</td>
<td>10-9</td>
<td>16-11</td>
<td>22-4</td>
<td>Note a</td>
</tr>
<tr>
<td>Spruce-Pine-Fir</td>
<td>#2</td>
<td>10-9</td>
<td>16-11</td>
<td>22-4</td>
<td>Note a</td>
</tr>
<tr>
<td>Spruce-Pine-Fir</td>
<td>#3</td>
<td>9-5</td>
<td>13-9</td>
<td>17-5</td>
<td>21-3</td>
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</tbody>
</table>

(Continued)
### TABLE 24.8.7.1(1)—continued CEILING JOIST SPANS FOR COMMON TIMBER SPECIES
(Uninhabitable attics without storage, live load = 10 psf, L/ = 240)

<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 5 psf</th>
</tr>
</thead>
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<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Maximum ceiling joint spans</td>
</tr>
<tr>
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<td>11-3</td>
<td>17-8</td>
</tr>
<tr>
<td>Douglas Fir-Larch #1</td>
<td>10-10</td>
<td>17-0</td>
</tr>
<tr>
<td>Douglas Fir-Larch #2</td>
<td>10-7</td>
<td>16-7</td>
</tr>
<tr>
<td>Douglas Fir-Larch #3</td>
<td>8-7</td>
<td>12-6</td>
</tr>
<tr>
<td>Hem-Fir SS</td>
<td>10-7</td>
<td>16-8</td>
</tr>
<tr>
<td>Hem-Fir #1</td>
<td>10-4</td>
<td>16-4</td>
</tr>
<tr>
<td>Hem-Fir #2</td>
<td>9-11</td>
<td>15-7</td>
</tr>
<tr>
<td>Hem-Fir #3</td>
<td>8-7</td>
<td>12-6</td>
</tr>
<tr>
<td>Southern Pine SS</td>
<td>11-0</td>
<td>17-4</td>
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<tr>
<td>Southern Pine #1</td>
<td>10-7</td>
<td>16-8</td>
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<td>11-9</td>
</tr>
<tr>
<td>Spruce-Pine-Fir SS</td>
<td>10-4</td>
<td>16-4</td>
</tr>
<tr>
<td>Spruce-Pine-Fir #1</td>
<td>10-2</td>
<td>15-11</td>
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<td>Spruce-Pine-Fir #2</td>
<td>10-2</td>
<td>15-11</td>
</tr>
<tr>
<td>Spruce-Pine-Fir #3</td>
<td>8-7</td>
<td>12-6</td>
</tr>
</tbody>
</table>

| Douglas Fir-Larch SS          | 10-5              | 16-4             | 21-7             | Note a            |
| Douglas Fir-Larch #1          | 10-0              | 15-9             | 20-1             | 24-6              |
| Douglas Fir-Larch #2          | 9-10              | 14-10            | 18-9             | 22-11             |
| Douglas Fir-Larch #3          | 7-8               | 11-2             | 14-2             | 17-4              |
| Hem-Fir SS                    | 9-10              | 15-6             | 20-5             | Note a            |
| Hem-Fir #1                    | 9-8               | 15-2             | 19-7             | 23-11             |
| Hem-Fir #2                    | 9-2               | 14-5             | 18-6             | 22-7              |
| Hem-Fir #3                    | 7-8               | 11-2             | 14-2             | 17-4              |
| Southern Pine SS              | 10-3              | 16-1             | 21-2             | Note a            |
| Southern Pine #1              | 9-10              | 15-6             | 20-5             | 24-0              |
| Southern Pine #2              | 9-3               | 13-11            | 17-7             | 20-11             |
| Southern Pine #3              | 7-2               | 10-6             | 13-3             | 16-1              |
| Spruce-Pine-Fir #1            | 9-5               | 14-9             | 18-9             | 22-11             |
| Spruce-Pine-Fir #2            | 9-5               | 14-9             | 18-9             | 22-11             |
| Spruce-Pine-Fir #3            | 7-8               | 11-2             | 14-2             | 17-4              |

**Note:** Check sources for availability of timber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

- **a.** Span exceeds 26 feet in length.
<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>(2 \times 4)</th>
<th>(2 \times 6)</th>
<th>(2 \times 8)</th>
<th>(2 \times 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maximum ceiling joist spans</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td>12</td>
<td>Douglas Fir-Larch SS</td>
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<td>16-4</td>
<td>21-7</td>
<td>Note a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch #1</td>
<td>16-0</td>
<td>15-9</td>
<td>20-1</td>
<td>24-6</td>
<td></td>
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<tr>
<td></td>
<td>Douglas Fir-Larch #2</td>
<td>9-10</td>
<td>14-10</td>
<td>18-9</td>
<td>22-11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch #3</td>
<td>7-8</td>
<td>11-2</td>
<td>14-2</td>
<td>17-4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hem-Fir SS</td>
<td>9-10</td>
<td>15-6</td>
<td>20-5</td>
<td>Note a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hem-Fir #1</td>
<td>9-8</td>
<td>15-2</td>
<td>19-7</td>
<td>23-11</td>
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<tr>
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<td>Hem-Fir #2</td>
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<td>14-5</td>
<td>18-6</td>
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<tr>
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<td>14-2</td>
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<tr>
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<td>Southern Pine SS</td>
<td>10-3</td>
<td>16-1</td>
<td>21-2</td>
<td>Note a</td>
<td></td>
</tr>
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<td>9-10</td>
<td>15-6</td>
<td>20-5</td>
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<td>Southern Pine #2</td>
<td>9-3</td>
<td>13-11</td>
<td>17-7</td>
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</tr>
<tr>
<td></td>
<td>Southern Pine #3</td>
<td>7-2</td>
<td>10-6</td>
<td>13-3</td>
<td>16-1</td>
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</tr>
<tr>
<td></td>
<td>Spruce-Fire Fir SS</td>
<td>9-8</td>
<td>15-2</td>
<td>19-11</td>
<td>25-5</td>
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</tr>
<tr>
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<td>Spruce-Fire Fir #1</td>
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<td>14-9</td>
<td>18-9</td>
<td>22-11</td>
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<td>Spruce-Fire Fir #2</td>
<td>9-5</td>
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<td>Spruce-Fire Fir #3</td>
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<td>16</td>
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<td>14-11</td>
<td>19-7</td>
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<td>Douglas Fir-Larch #1</td>
<td>9-1</td>
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<tr>
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<td>8-9</td>
<td>12-10</td>
<td>16-3</td>
<td>18-10</td>
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</tr>
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<td>Douglas Fir-Larch #3</td>
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<td>9-8</td>
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<tr>
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<td>14-1</td>
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<td>Southern Pine SS</td>
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<td>14-7</td>
<td>19-3</td>
<td>24-7</td>
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</tr>
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<td>Southern Pine #1</td>
<td>8-11</td>
<td>14-0</td>
<td>17-9</td>
<td>20-9</td>
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<td>Southern Pine #2</td>
<td>8-0</td>
<td>12-0</td>
<td>15-3</td>
<td>18-1</td>
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<td>14-0</td>
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<td>8-9</td>
<td>13-9</td>
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<td>12-10</td>
<td>16-3</td>
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<td>6-8</td>
<td>9-8</td>
<td>12-4</td>
<td>15-0</td>
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</tbody>
</table>

(continued)
### TABLE 24.8.7.1(2)—continued CEILING JOIST SPANS FOR COMMON TIMBER SPECIES
(Uninhabitable attics with limited storage, live load = 20 psf, L/4 = 240)

<table>
<thead>
<tr>
<th>CEILING JOIST SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td>19.2</td>
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<tr>
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<td>Douglas Fir-Larch #2</td>
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<td>Douglas Fir-Larch #3</td>
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</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>8-5</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#1</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#2</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#3</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>8-9</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td>Southern Pine      #2</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
<td>Southern Pine      #3</td>
<td>5-8</td>
</tr>
<tr>
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<td>Spruce-Pine-Fir</td>
<td>8-3</td>
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<td>Spruce-Pine-Fir    #2</td>
<td>8-0</td>
</tr>
<tr>
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<td>Spruce-Pine-Fir    #3</td>
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<td>24</td>
<td>Douglas Fir-Larch</td>
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<tr>
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<td>Douglas Fir-Larch #2</td>
<td>7-2</td>
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<tr>
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<td>Douglas Fir-Larch #3</td>
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<tr>
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<td>Hem-Fir</td>
<td>7-10</td>
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<tr>
<td></td>
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<td>#1</td>
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<tr>
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<td>Hem-Fir</td>
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<td>7-2</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir    #2</td>
<td>7-2</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir    #3</td>
<td>5-5</td>
</tr>
</tbody>
</table>

**Note:** Check sources for availability of timber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. Span exceeds 26 feet in length.
24.8.6.7.2 Top plate connection.

Where joists or rafters are used, braced wall line top plates shall be fastened over the full length of the braced wall line to joists, rafters, rim boards or full-depth blocking above in accordance with Table 24.4.10.1, as applicable, based on the orientation of the joists or rafters to the braced wall line. Blocking shall be not less than 51 mm (2 inches) in nominal thickness and shall be fastened to the braced wall line top plate as specified in Table 24.4.10.1. Notching or drilling of holes in blocking in accordance with the requirements of Clause 24.8.4.2.4 or 24.8.7.4 shall be permitted.

Exception: Where the roof sheathing is greater than 235 mm (9\(\frac{3}{4}\) inches) above the top plate, solid blocking is not required where the framing members are connected using one of the following methods:

1. In accordance with Figure 24.8.6.7.2(1).

2. In accordance with Figure 24.8.6.7.2(2).

3. Full-height engineered blocking panels designed for values listed in AWC WFCM.

4. A design in accordance with accepted engineering methods.

At exterior gable end walls, braced wall panel sheathing in the top storey shall be extended and fastened to the roof framing where the spacing between parallel exterior braced wall lines is greater than 15 240 mm (50 feet).

Where roof trusses are used and are installed perpendicular to an exterior braced wall line, lateral forces shall be transferred from the roof diaphragm to the braced wall over the full length of the braced wall line by blocking of the ends of the trusses or by other approved methods providing equivalent lateral force transfer. Blocking shall be not less than 51 mm (2 inches) in nominal thickness and equal to the depth of the truss at the wall line and shall be fastened to the braced wall line top plate as specified in Table 24.4.10.1. Notching or drilling of holes in blocking in accordance with the requirements of Clause 24.8.4.2.4 or 24.8.7.4 shall be permitted.

Exception: Where the roof sheathing is greater than 235 mm (9\(\frac{3}{4}\) inches) above the top plate, solid blocking is not required where the framing members are connected using one of the following methods:
FIGURE 24.8.6.7.2(1) BRACED WALL LINE TOP PLATE CONNECTION

Note: For SI: 1 foot = 304.8 mm.
Note: For SI: 1 foot = 304.8 mm.

FIGURE 24.8.6.7.2(2) BRACED WALL PANEL TOP PLATE CONNECTION
<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th><strong>DEAD LOAD = 10 psf</strong></th>
<th><strong>DEAD LOAD = 20 psf</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch SS</td>
<td>11-6</td>
<td>18-0</td>
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<tr>
<td></td>
<td>Douglas Fir-Larch #1</td>
<td>11-1</td>
<td>17-4</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch #2</td>
<td>10-10</td>
<td>16-7</td>
</tr>
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<td></td>
<td>Douglas Fir-Larch #3</td>
<td>8-7</td>
<td>12-6</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir SS</td>
<td>10-10</td>
<td>17-0</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir #1</td>
<td>10-7</td>
<td>16-8</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir #3</td>
<td>8-7</td>
<td>12-6</td>
</tr>
<tr>
<td></td>
<td>Southern Pine SS</td>
<td>11-3</td>
<td>17-8</td>
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<tr>
<td></td>
<td>Southern Pine #1</td>
<td>10-10</td>
<td>17-0</td>
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<td>Southern Pine #3</td>
<td>8-0</td>
<td>11-9</td>
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<td>Spruce-Pine-Fir SS</td>
<td>10-7</td>
<td>16-8</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #1</td>
<td>10-4</td>
<td>16-3</td>
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<tr>
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<td>Spruce-Pine-Fir #2</td>
<td>10-4</td>
<td>16-3</td>
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<tr>
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<td>Spruce-Pine-Fir #3</td>
<td>8-7</td>
<td>12-6</td>
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</tbody>
</table>

(continued)
### TABLE 24.8.7.2(1)—continued RAFTER SPANS FOR COMMON TIMBER SPECIES
(Roof live load = 20 psf, ceiling not attached to rafters, L/1 = 180)

<table>
<thead>
<tr>
<th>RAFTER SPACING (Inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
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<td>Douglas Fir-Larch SS</td>
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</tr>
<tr>
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<tr>
<td></td>
<td>Douglas Fir-Larch #3</td>
<td>6-1</td>
<td>8-10</td>
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<tr>
<td></td>
<td>Hem-Fir SS</td>
<td>8-7</td>
<td>13-6</td>
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<tr>
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<td>Hem-Fir #1</td>
<td>8-4</td>
<td>12-3</td>
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<td>Hem-Fir #2</td>
<td>7-11</td>
<td>11-7</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir #3</td>
<td>6-1</td>
<td>8-10</td>
</tr>
<tr>
<td></td>
<td>Southern Pine SS</td>
<td>8-11</td>
<td>14-1</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir SS</td>
<td>8-5</td>
<td>13-3</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #1</td>
<td>8-0</td>
<td>11-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #2</td>
<td>8-0</td>
<td>11-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #3</td>
<td>6-1</td>
<td>8-10</td>
</tr>
</tbody>
</table>

**Note:** Check sources for availability of timber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

<table>
<thead>
<tr>
<th>$\frac{H_C}{H_R}$</th>
<th>Rafter Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
</tr>
<tr>
<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>

where:

- $H_C$ = Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.
- $H_R$ = Height of roof ridge measured vertically above the top of the rafter support walls.

b. Span exceeds 26 feet in length.
<table>
<thead>
<tr>
<th>RAFTER SPACING (Inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft.-in.)</td>
<td>(ft.-in.)</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>10-5</td>
<td>16-4</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#1</td>
<td>10-0</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#2</td>
<td>9-10</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#3</td>
<td>8-7</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS</td>
<td>9-10</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#1</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#2</td>
<td>9-2</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#3</td>
<td>8-7</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS</td>
<td>10-3</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#1</td>
<td>9-10</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>#2</td>
<td>9-5</td>
</tr>
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<td></td>
<td>Southern Pine</td>
<td>#3</td>
<td>8-0</td>
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<td>Spruce-Pine-Fir</td>
<td>#1</td>
<td>9-5</td>
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<tr>
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<td>Spruce-Pine-Fir</td>
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</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#3</td>
<td>8-7</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 24.8.7.2(2)—continued
RAFTER SPANS FOR COMMON TIMBER SPECIES
(Roof live load = 20 psf, ceiling attached to rafters, L/[%20 = 240)

<table>
<thead>
<tr>
<th>Rafter Spacing (inches)</th>
<th>Species and Grade</th>
<th>Dead Load = 10 psf</th>
<th>2 x 4</th>
<th>2 x 6</th>
<th>2 x 8</th>
<th>2 x 10</th>
<th>2 x 12</th>
<th>2 x 4</th>
<th>2 x 6</th>
<th>2 x 8</th>
<th>2 x 10</th>
<th>2 x 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
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<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td>19.2</td>
<td>Southern Pine SS</td>
<td>8-9</td>
<td>13-9</td>
<td>18-2</td>
<td>21-2</td>
<td>21-9</td>
<td>7-1</td>
<td>10-8</td>
<td>13-6</td>
<td>18-2</td>
<td>23-1</td>
<td>Note b</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #1</td>
<td>8-5</td>
<td>13-3</td>
<td>17-5</td>
<td>21-2</td>
<td>25-2</td>
<td>8-4</td>
<td>12-4</td>
<td>15-8</td>
<td>18-4</td>
<td>21-9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southern Pine #2</td>
<td>8-1</td>
<td>12-3</td>
<td>15-7</td>
<td>18-6</td>
<td>21-9</td>
<td>7-1</td>
<td>10-8</td>
<td>13-6</td>
<td>16-0</td>
<td>18-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Southern Pine #3</td>
<td>6-4</td>
<td>9-4</td>
<td>11-9</td>
<td>14-3</td>
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<td>5-6</td>
<td>8-1</td>
<td>10-2</td>
<td>12-4</td>
<td>14-7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir SS</td>
<td>8-3</td>
<td>12-11</td>
<td>17-1</td>
<td>21-9</td>
<td>Note b</td>
<td>8-3</td>
<td>12-11</td>
<td>17-1</td>
<td>21-0</td>
<td>24-4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #1</td>
<td>8-1</td>
<td>12-8</td>
<td>16-7</td>
<td>20-3</td>
<td>23-6</td>
<td>7-9</td>
<td>11-4</td>
<td>14-4</td>
<td>17-7</td>
<td>20-4</td>
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<tr>
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<td>12-8</td>
<td>16-7</td>
<td>20-3</td>
<td>23-6</td>
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<td>11-4</td>
<td>14-4</td>
<td>17-7</td>
<td>20-4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #3</td>
<td>6-9</td>
<td>9-11</td>
<td>12-7</td>
<td>15-4</td>
<td>17-9</td>
<td>5-10</td>
<td>8-7</td>
<td>11-0</td>
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<td>15-5</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Hc / Hr</th>
<th>Rafter Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
</tr>
<tr>
<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note:
Check sources for availability of timber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

$$
\frac{H_c}{H_r} \times \text{Rafter Span Adjustment Factor}
$$

where:
\[ H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.} \]

\[ H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.} \]

b. Span exceeds 26 feet in length.
### TABLE 24.8.7.2(3) RAFTER SPANS FOR COMMON TIMBER SPECIES
(Ground snow load = 30 psf, ceiling not attached to rafters, L/180)

<table>
<thead>
<tr>
<th>RAFTER SPACING (Inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>SS 10-0</td>
<td>15-9</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#1 9-8</td>
<td>14-9</td>
</tr>
<tr>
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<td>Douglas Fir-Larch</td>
<td>#2 9-5</td>
<td>13-9</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#3 7-1</td>
<td>10-5</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS 9-6</td>
<td>14-10</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#1 9-3</td>
<td>14-4</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
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<td>13-7</td>
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</tr>
<tr>
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<td>Southern Pine</td>
<td>SS 9-10</td>
<td>15-6</td>
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<tr>
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<td>Southern Pine</td>
<td>#1 9-6</td>
<td>14-10</td>
</tr>
<tr>
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<td>Southern Pine</td>
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</tr>
<tr>
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<td>Southern Pine</td>
<td>#3 6-7</td>
<td>9-9</td>
</tr>
<tr>
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<td>Spruce-Pine-Fir</td>
<td>SS 9-3</td>
<td>14-7</td>
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<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#1 9-1</td>
<td>13-9</td>
</tr>
<tr>
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<td>Spruce-Pine-Fir</td>
<td>#2 9-1</td>
<td>13-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#3 7-1</td>
<td>10-5</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>SS 9-1</td>
<td>14-4</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>#1 8-9</td>
<td>12-9</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
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</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS 8-7</td>
<td>13-6</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>#1 8-5</td>
<td>12-5</td>
</tr>
<tr>
<td></td>
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<td>#3 6-2</td>
<td>9-0</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS 8-11</td>
<td>14-1</td>
</tr>
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<td></td>
<td>Southern Pine</td>
<td>#1 8-7</td>
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<td>11-2</td>
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<td></td>
<td>Spruce-Pine-Fir</td>
<td>#1 8-2</td>
<td>11-11</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#2 8-2</td>
<td>11-11</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>#3 6-2</td>
<td>9-0</td>
</tr>
</tbody>
</table>

(Continued)
### TABLE 24.8.7.2(3)—continued RAFTER SPANS FOR COMMON TIMBER SPECIES  
(Ground snow load = 30 psf, ceiling not attached to rafters, \( L/\phi = 180 \))

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft.-in.)</td>
<td>(ft.-in.)</td>
</tr>
<tr>
<td>19.2</td>
<td>Southern Pine SS</td>
<td>8-5</td>
<td>13-3</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #1</td>
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<td>11-10</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #2</td>
<td>6-10</td>
<td>10-2</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #3</td>
<td>5-3</td>
<td>7-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir SS</td>
<td>7-11</td>
<td>12-5</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #1</td>
<td>7-5</td>
<td>10-11</td>
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<td>Spruce-Pine-Fir #2</td>
<td>7-5</td>
<td>10-11</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #3</td>
<td>5-7</td>
<td>8-3</td>
</tr>
<tr>
<td>24</td>
<td>Douglas Fir-Larch SS</td>
<td>7-11</td>
<td>12-6</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch #1</td>
<td>7-1</td>
<td>10-5</td>
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<tr>
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<td>6-8</td>
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<tr>
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<td>11-10</td>
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<tr>
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<td>6-11</td>
<td>10-2</td>
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<tr>
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<td>Spruce-Pine-Fir #3</td>
<td>5-0</td>
<td>7-4</td>
</tr>
</tbody>
</table>

**Note:**
Check sources for availability of timber in lengths greater than 20 feet.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

<table>
<thead>
<tr>
<th>( \frac{H_c}{H_R} )</th>
<th>Rafter Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
</tr>
<tr>
<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>
where:

\[ H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.} \]

\[ H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.} \]

b. Span exceeds 26 feet in length.
### TABLE 24.8.7.2(4) RAFTER SPANS FOR COMMON TIMBER SPECIES
(Ground snow load = 50 psf, ceiling not attached to rafters, L/ = 180)

<table>
<thead>
<tr>
<th>RAFTER SPACING (Inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft.-in.)</td>
<td>(ft.-in.)</td>
</tr>
<tr>
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<td>8-5</td>
<td>13-3</td>
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<tr>
<td></td>
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<td>8-2</td>
<td>12-0</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch #2</td>
<td>7-8</td>
<td>11-3</td>
</tr>
<tr>
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<td>Douglas Fir-Larch #3</td>
<td>5-10</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir SS</td>
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<td>11-9</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir #2</td>
<td>7-5</td>
<td>11-1</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir #3</td>
<td>5-10</td>
<td>8-6</td>
</tr>
<tr>
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<td>Southern Pine #2</td>
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<td>8-0</td>
</tr>
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<td>7-10</td>
<td>12-3</td>
</tr>
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<td>Spruce-Pine-Fir #1</td>
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</tr>
<tr>
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<td>Spruce-Pine-Fir #2</td>
<td>7-8</td>
<td>11-3</td>
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<td></td>
<td>Douglas Fir-Larch #3</td>
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<td>7-4</td>
</tr>
<tr>
<td></td>
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<td>Hem-Fir #2</td>
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</tr>
<tr>
<td></td>
<td>Hem-Fir #3</td>
<td>5-0</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
<td>Southern Pine SS</td>
<td>7-6</td>
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<td>Spruce-Pine-Fir #3</td>
<td>5-0</td>
<td>7-4</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 24.8.7.2(4) RAFTER SPANS FOR COMMON TIMBER SPECIES

**Note:**
Check sources for availability of timber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:

<table>
<thead>
<tr>
<th>( \frac{H}{R} )</th>
<th>Rafters Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
</tr>
<tr>
<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td></td>
<td>2 x 4</td>
<td>2 x 6</td>
<td>2 x 8</td>
</tr>
<tr>
<td>19.2</td>
<td>Southern Pine SS</td>
<td>7-1</td>
<td>11-2</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #1</td>
<td>6-6</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #2</td>
<td>5-7</td>
<td>8-4</td>
</tr>
<tr>
<td></td>
<td>Southern Pine #3</td>
<td>4-3</td>
<td>6-4</td>
</tr>
<tr>
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<tr>
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<td>8-11</td>
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<tr>
<td></td>
<td>Spruce-Pine-Fir #2</td>
<td>6-1</td>
<td>8-11</td>
</tr>
<tr>
<td>24</td>
<td>Spruce-Pine-Fir #3</td>
<td>4-7</td>
<td>6-9</td>
</tr>
<tr>
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<td>Douglas Fir-Larch SS</td>
<td>6-8</td>
<td>10-3</td>
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<tr>
<td></td>
<td>Douglas Fir-Larch #1</td>
<td>5-10</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch #2</td>
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<td>7-11</td>
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<tr>
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<td>Douglas Fir-Larch #3</td>
<td>4-1</td>
<td>6-0</td>
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<td>Hem-Fir #2</td>
<td>5-4</td>
<td>7-10</td>
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<td>Hem-Fir #3</td>
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<td>6-0</td>
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<td>Southern Pine #3</td>
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<td>9-6</td>
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<td></td>
<td>Spruce-Pine-Fir #1</td>
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<tr>
<td></td>
<td>Spruce-Pine-Fir #2</td>
<td>5-5</td>
<td>7-11</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #3</td>
<td>4-1</td>
<td>6-0</td>
</tr>
</tbody>
</table>
where:

\[ H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.} \]

\[ H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.} \]

b. Span exceeds 26 feet in length.
<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(ft. - in.)</td>
<td>(ft. - in.)</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>9-1</td>
<td>14-4</td>
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<tr>
<td></td>
<td>Douglas Fir-Larch</td>
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<td>13-6</td>
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<td>10-5</td>
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<td>8-7</td>
<td>13-6</td>
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<td>Hem-Fir</td>
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<tr>
<td></td>
<td>Hem-Fir</td>
<td>8-0</td>
<td>12-7</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
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<td>10-5</td>
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<td>Southern Pine</td>
<td>8-11</td>
<td>14-1</td>
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<td>12-11</td>
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<tr>
<td></td>
<td>Southern Pine</td>
<td>6-7</td>
<td>9-9</td>
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<tr>
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<td>Spruce-Pine-Fir</td>
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<td>13-3</td>
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<td></td>
<td>Spruce-Pine-Fir</td>
<td>8-3</td>
<td>12-11</td>
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<td>Spruce-Pine-Fir</td>
<td>8-3</td>
<td>12-11</td>
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<td>10-5</td>
</tr>
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<td>8-3</td>
<td>13-0</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
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<td>12-6</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td>6-2</td>
<td>9-0</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>7-10</td>
<td>12-3</td>
</tr>
<tr>
<td></td>
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<td>Spruce-Pine-Fir</td>
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<td>9-0</td>
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<td>10-11</td>
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<td>5-7</td>
<td>8-3</td>
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<tr>
<td></td>
<td>Hem-Fir</td>
<td>7-4</td>
<td>11-7</td>
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<td>11-4</td>
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<td>Hem-Fir</td>
<td>5-7</td>
<td>8-3</td>
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</tbody>
</table>

| rafter spans * |

<table>
<thead>
<tr>
<th>Maximum rafter spans</th>
<th>(ft. - in.)</th>
<th>(ft. - in.)</th>
<th>(ft. - in.)</th>
<th>(ft. - in.)</th>
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<tbody>
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</table>

820
(continued)

### TABLE 24.8.7.2(5)—continued RAFTER SPANS FOR COMMON TIMBER SPECIES
(Ground snow load = 30 psf, ceiling attached to rafters, L/24 = 240)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4 (ft. in.)</td>
<td>2 x 6 (ft. in.)</td>
</tr>
<tr>
<td>19.2</td>
<td>Southern Pine SS</td>
<td>7-8</td>
<td>12-0</td>
</tr>
<tr>
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<td>Southern Pine #1</td>
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</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir SS</td>
<td>7-2</td>
<td>11-4</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #1</td>
<td>7-0</td>
<td>10-11</td>
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<tr>
<td></td>
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</tr>
<tr>
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<td>5-7</td>
<td>8-3</td>
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<tr>
<td>24</td>
<td>Douglas Fir-Larch SS</td>
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<td>11-4</td>
</tr>
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<td>10-5</td>
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<td></td>
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<td>6-8</td>
<td>9-9</td>
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<tr>
<td></td>
<td>Douglas Fir-Larch #3</td>
<td>5-0</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
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<tr>
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</tr>
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<td>11-2</td>
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<tr>
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<td>Southern Pine #1</td>
<td>6-10</td>
<td>10-7</td>
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<tr>
<td></td>
<td>Southern Pine #3</td>
<td>4-8</td>
<td>6-11</td>
</tr>
<tr>
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<td>Spruce-Pine-Fir SS</td>
<td>6-8</td>
<td>10-6</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #1</td>
<td>6-6</td>
<td>9-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #2</td>
<td>6-6</td>
<td>9-9</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir #3</td>
<td>5-0</td>
<td>7-4</td>
</tr>
</tbody>
</table>

Check sources for availability of timber in lengths greater than 20 feet. For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:
<table>
<thead>
<tr>
<th>$\frac{H_C}{H_R}$</th>
<th>Rafter Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
</tr>
<tr>
<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>

where:

- $H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.}$
- $H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.}$

b. Span exceeds 26 feet in length.
## TABLE 24.8.7.2(6) RAFTER SPANS FOR COMMON TIMBER SPECIES
(Ground snow load = 50 psf, ceiling attached to rafters, L/Ω = 240)

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 6</td>
</tr>
<tr>
<td></td>
<td>Douglas Fir-Larch</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SS</td>
<td>7-8</td>
<td>12-1</td>
</tr>
<tr>
<td></td>
<td>#1</td>
<td>7-5</td>
<td>11-7</td>
</tr>
<tr>
<td></td>
<td>#2</td>
<td>7-3</td>
<td>11-3</td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td>5-10</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SS</td>
<td>7-3</td>
<td>11-5</td>
</tr>
<tr>
<td></td>
<td>#1</td>
<td>7-1</td>
<td>11-2</td>
</tr>
<tr>
<td></td>
<td>#2</td>
<td>6-9</td>
<td>10-8</td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td>5-10</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SS</td>
<td>7-6</td>
<td>11-10</td>
</tr>
<tr>
<td></td>
<td>#1</td>
<td>7-3</td>
<td>11-5</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>#2</td>
<td>6-11</td>
<td>10-6</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td>5-5</td>
<td>8-0</td>
</tr>
<tr>
<td></td>
<td>Spuce-Pine-Fir</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SS</td>
<td>7-1</td>
<td>11-2</td>
</tr>
<tr>
<td></td>
<td>#1</td>
<td>6-11</td>
<td>10-11</td>
</tr>
<tr>
<td></td>
<td>Spuce-Pine-Fir</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>#2</td>
<td>6-11</td>
<td>10-11</td>
</tr>
<tr>
<td></td>
<td>Spuce-Pine-Fir</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td>5-10</td>
<td>8-6</td>
</tr>
</tbody>
</table>

823
TABLE 27.8.7.2(6)—continued RAFTER SPANS FOR COMMON TIMBER SPECIES

(Ground snow load = 50 psf, ceiling attached to rafters, \( L/h = 240 \))

<table>
<thead>
<tr>
<th>RAFTER SPACING (inches)</th>
<th>SPECIES AND GRADE</th>
<th>DEAD LOAD = 10 psf</th>
<th>DEAD LOAD = 20 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 x 4</td>
<td>2 x 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ft.-in.)</td>
<td>(ft.-in.)</td>
</tr>
<tr>
<td>19.2</td>
<td>Southern Pine</td>
<td>SS 6-5</td>
<td>10-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 6-2</td>
<td>9-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 5-7</td>
<td>8-4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 4-3</td>
<td>6-4</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS 6-1</td>
<td>9-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 5-11</td>
<td>8-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 5-11</td>
<td>8-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 4-7</td>
<td>6-9</td>
</tr>
<tr>
<td>24</td>
<td>Douglas Fir-Larch</td>
<td>SS 6-1</td>
<td>9-7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 5-10</td>
<td>8-6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 5-5</td>
<td>7-11</td>
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<tr>
<td></td>
<td></td>
<td>#3 4-1</td>
<td>6-0</td>
</tr>
<tr>
<td></td>
<td>Hem-Fir</td>
<td>SS 5-9</td>
<td>9-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 5-8</td>
<td>8-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 5-4</td>
<td>7-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 4-1</td>
<td>6-0</td>
</tr>
<tr>
<td></td>
<td>Southern Pine</td>
<td>SS 6-0</td>
<td>9-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 5-9</td>
<td>8-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 5-0</td>
<td>7-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 3-10</td>
<td>5-8</td>
</tr>
<tr>
<td></td>
<td>Spruce-Pine-Fir</td>
<td>SS 5-8</td>
<td>8-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#1 5-5</td>
<td>7-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 5-5</td>
<td>7-11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 4-1</td>
<td>6-0</td>
</tr>
</tbody>
</table>

Note:
Check sources for availability of timber in lengths greater than 20 feet.
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.

a. The tabulated rafter spans assume that ceiling joists are located at the bottom of the attic space or that some other method of resisting the outward push of the rafters on the bearing walls, such as rafter ties, is provided at that location. Where ceiling joists or rafter ties are located higher in the attic space, the rafter spans shall be multiplied by the following factors:
<table>
<thead>
<tr>
<th>$\frac{H_C}{H_R}$</th>
<th>Rafter Span Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td>0.67</td>
</tr>
<tr>
<td>1/4</td>
<td>0.76</td>
</tr>
<tr>
<td>1/5</td>
<td>0.83</td>
</tr>
<tr>
<td>1/6</td>
<td>0.90</td>
</tr>
<tr>
<td>1/7.5 or less</td>
<td>1.00</td>
</tr>
</tbody>
</table>

where:

\[
H_C = \text{Height of ceiling joists or rafter ties measured vertically above the top of the rafter support walls.}
\]

\[
H_R = \text{Height of roof ridge measured vertically above the top of the rafter support walls.}
\]

24.8.6.7.3 Sill anchorage.

Where foundations are required by Clause 24.8.6.8, braced wall line sills shall be anchored to concrete or masonry foundations. Such anchorage shall conform to the requirements of Clause 24.8.3. The anchors shall be distributed along the length of the braced wall line. Other anchorage devices having equivalent capacity are permitted.
### TABLE 24.8.7.3.1 RAFTER TIE CONNECTIONS

<table>
<thead>
<tr>
<th>RAFTER SLOPE</th>
<th>TIE SPACING (inches)</th>
<th>NO SNOW LOAD</th>
<th>GROUND SNOW LOAD (pound per square foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30 pounds per square foot</td>
<td>50 pounds per square foot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>3:12</td>
<td>12</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>4:12</td>
<td>12</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>5:12</td>
<td>12</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>4</td>
<td>6</td>
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<tr>
<td></td>
<td>32</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>7:12</td>
<td>12</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>9:12</td>
<td>12</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>12:12</td>
<td>12</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
24.8.6.7.4 Anchorage to all-wood foundations.

Where all-wood foundations are used, the force transfer from the braced wall lines shall be determined based on calculation and shall have a capacity that is not less than the connections required by Clause 24.8.3.

24.8.6.8 Braced wall line and diaphragm support.

Braced wall lines and floor and roof diaphragms shall be supported in accordance with this clause.

24.8.6.8.1 Foundation requirements.

Braced wall lines shall be supported by continuous foundations.

Exception: For structures with a maximum plan dimension not more than 50 feet (15 240 mm), continuous foundations are required at exterior walls only.

For structures in Seismic Design Categories D and E, exterior braced wall panels shall be in the same plane vertically with the foundation or the portion of the structure containing the offset shall be designed in accordance with accepted engineering practice and Clause 24.8.1.1.

Exceptions:

1. Exterior braced wall panels shall be permitted to be located not more than 1219 mm (4 feet) from the foundation below where supported by a floor constructed in accordance with all of the following:

   a. Nailing requirements are permitted to be reduced 25 percent if nails are clinched.
   b. Equivalent nailing patterns are required for ceiling joist to ceiling joist lap splices.
   c. Connected members shall be of sufficient size to prevent splitting due to nailing.
   d. For snow loads less than 30 pounds per square foot, the required number of nails is permitted to be reduced by multiplying by the ratio of actual snow load plus 10 divided by 40, but not less than the number required for no snow load.

1.1. Cantilevers or setbacks shall not exceed four times the nominal depth of the floor joists.

1.2. Floor joists shall be 51 mm by 254 mm (2 inches by 10 inches) or larger and spaced not more than 406 mm (16 inches) on center.

1.3. The ratio of the back span to the cantilever shall be not less than 2 to 1.

1.4. Floor joists at ends of braced wall panels shall be doubled.

1.5. A continuous rim joist shall be connected to the ends of cantilevered joists. The rim joist is permitted to be spliced using a metal tie not less than 1.47 mm (0.058 inch) (16 galvanized gage) and 38 mm (1 1/2 inches) in width fastened with six 16d common nails on each side. The metal tie shall have a yield stress not less than 227 MPa (33,000 psi).

1.6. Joists at setbacks or the end of cantilevered joists shall not carry gravity loads from more than a single storey having uniform wall and roof loads nor carry the reactions from headers having a span of 2438 mm (8 feet) or more.

2. The end of a required braced wall panel shall be allowed to extend not more than
305 mm (1 foot) over an opening in the wall below. This requirement is applicable to braced wall panels offset in plane and braced wall panels offset out of plane as permitted by Exception 1. Braced wall panels are permitted to extend over an opening not more than 2438 mm (8 feet) in width where the header is a 102 mm by 305 mm (4-inch by 12-inch) or larger member.

24.8.6.8.2 Floor and roof diaphragm support in Seismic Design Categories D and E.
In structures assigned to Seismic Design Categories D or E, floor and roof diaphragms shall be laterally supported by braced wall lines on all edges and connected in accordance with Clause 24.8.6.7 [see Figure 2308.6.8.2(1)].

Exception: Portions of roofs or floors that do not support braced wall panels above are permitted to extend up to 6 feet (1829 mm) beyond a braced wall line [see Figure 2308.6.8.2(2)] provided that the framing members are connected to the braced wall line below in accordance with Clause 24.8.6.7.

Note: For SI: 1 foot = 304.8 mm.

FIGURE 2308.6.8.2(2) ROOF EXTENSION IN SDC D OR E BEYOND BRACED WALL LINE

24.8.6.8.3 Stepped footings in Seismic Design Categories B, C, D and E.
In Seismic Design Categories B, C, D and E, where the height of a required braced wall panel extending from foundation to floor above varies more than 1219 mm (4 feet), the following construction shall be used:

1. Where the bottom of the footing is stepped and the lowest floor framing rests directly on a sill bolted to the footings, the sill shall be anchored as required in Clause 24.8.3.

2. Where the lowest floor framing rests directly on a sill bolted to a footing not less than 2438 mm (8 feet) in length along a line of bracing, the line shall be considered to be braced. The double plate of the cripple stud wall beyond the segment of footing extending to the lowest framed floor shall be spliced to the sill plate with metal ties, one on each side of the sill and plate. The metal ties shall be not less than 0.058 inch (1.47 mm (16 galvanized gage)] by 38 mm
(1\frac{1}{2} \text{ inches}) in width by 1219 mm (48 inches) with eight 16d common nails on each side of the splice location (see Figure 2308.6.8.3). The metal tie shall have a yield stress not less than 33,000 pounds per square inch (psi) (227 MPa).

3. Where cripple walls occur between the top of the footing and the lowest floor framing, the bracing requirements for a storey shall apply.

In Seismic Design Categories B and C, concrete or masonry walls and stone or masonry veneer shall not extend above a basement.

**Exceptions:**

1. In structures assigned to Seismic Design Category B, stone and masonry veneer is permitted to be used in the first two stories above grade plane or the first three stories above grade plane where the lowest storey has concrete or masonry walls, provided that wood structural panel wall bracing is used and the length of bracing provided is one and one-half times the required length specified in Table 24.8.6.1.

2. Stone and masonry veneer is permitted to be used in the first storey above grade plane or the first two stories above grade plane where the lowest storey has concrete or masonry walls.

3. Stone and masonry veneer is permitted to be used in both stories of buildings with two stories above grade plane, provided that the following criteria are met:

   3.1. Type of brace in accordance with Clause 24.8.6.1 shall be WSP and the allowable shear capacity in accordance with Clause 24.6.3 shall be not less than 350 plf (5108 N/m).

   3.2. Braced wall panels in the second storey shall be located in accordance with Clause 24.8.6.1 and not more than 7620 mm (25 feet) on center, and the total length of braced wall panels shall be not less than 25 percent of the braced wall line length. Braced wall panels in the first storey shall be located in accordance with Clause 24.8.6.1.

---

**FIGURE 24.8.6.8.3 STEPPED FOOTING CONNECTION DETAILS**

**24.8.6.9 Attachment of sheathing.**

Fastening of braced wall panel sheathing shall be not less than that prescribed in Tables 24.8.6.1 and 24.4.10.1. Wall sheathing shall not be attached to framing members by adhesives.

**24.8.6.10 Limitations of concrete or masonry veneer.**

Concrete or masonry veneer shall comply with Part 15 and this clause.

**2308.6.10.1 Limitations of concrete or masonry veneer in Seismic Design Category B or C.**
and not more than 7620 mm (25 feet) on center, and the total length of braced wall panels shall be not less than 45 percent of the braced wall line length.

3.3. Hold-down connectors with an allowable capacity of 8896 N (2,000 pounds) shall be provided at the ends of each braced wall panel for the second storey to the first storey connection. Hold-down connectors with an allowable capacity of 17347 N (3,900 pounds) shall be provided at the ends of each braced wall panel for the first storey to the foundation connection. In all cases, the hold-down connector force shall be transferred to the foundation.

3.4. Cripple walls shall not be permitted.

24.8.6.10.2 Limitations of concrete or masonry in Seismic Design Categories D and E.

In Seismic Design Categories D and E, concrete or masonry walls and stone or masonry veneer shall not extend above a basement.

Exception: In structures assigned to Seismic Design Category D, stone and masonry veneer is permitted to be used in the first storey above grade plane, provided that the following criteria are met:

1. Type of brace in accordance with Clause 24.8.6.1 shall be WSP and the allowable shear capacity in accordance with Clause 24.6.3 shall be not less than 350 plf (5108 N/m).

2. The braced wall panels in the first storey shall be located at each end of the braced wall line and not more than 25 feet (7620 mm) on center, and the total length of braced wall panels shall be not less than 45 percent of the braced wall line length.

3. Hold-down connectors shall be provided at the ends of braced walls for the first floor to foundation with an allowable capacity of 2,100 pounds (9341 N).

4. Cripple walls shall not be permitted.

24.8.7 Roof and ceiling framing.

The framing details required in this clause apply to roofs having a slope of not less than three units vertical in 12 units horizontal (25-percent slope). Where the roof slope is less than three units vertical in 12 units horizontal (25-percent slope), members supporting rafters and ceiling joists such as ridge board, hips and valleys shall be designed as beams.

24.8.7.1 Ceiling joist spans.

Spans for ceiling joists shall be in accordance with Table 24.8.7.1(1) or 24.8.7.1(2). For other grades and species, and other loading conditions, refer to the AWC STJR.

24.8.7.2 Rafter spans.

Spans for rafters shall be in accordance with Table 24.8.7.2(1), 24.8.7.2(2), 24.8.7.2(3), 24.8.7.2(4), 24.8.7.2(5) or 24.8.7.2(6). For other grades and species and other loading conditions, refer to the AWC STJR. The span of each rafter shall be measured along the horizontal projection of the rafter.

24.8.7.3 Ceiling joist and rafter framing.

Rafters shall be framed directly opposite each other at the ridge. There shall be a ridge board not less than 25 mm (1-inch) nominal thickness at ridges and not less in depth than the cut end of the rafter. At valleys and hips, there shall be a single valley or hip rafter not less than 51 mm
(2-inch) nominal thickness and not less in depth than the cut end of the rafter.

24.8.7.3.1 Ceiling joist and rafter connections.

Ceiling joists and rafters shall be nailed to each other and the assembly shall be nailed to the top wall plate in accordance with Tables 24.4.10.1 and 24.8.7.5. Ceiling joists shall be continuous or securely joined where they meet over interior partitions and be fastened to adjacent rafters in accordance with Tables 24.4.10.1 and 24.8.7.3.1 to provide a continuous rafter tie across the building where such joists are parallel to the rafters. Ceiling joists shall have a bearing surface of not less than 38 mm (1 1/2 inches) on the top plate at each end. Where ceiling joists are not parallel to rafters, an equivalent rafter tie shall be installed in a manner to provide a continuous tie across the building, at a spacing of not more than 1219 mm (4 feet) on center. The connections shall be in accordance with Tables 24.8.7.3.1 and 24.4.10.1, or connections of equivalent capacities shall be provided. Where ceiling joists or rafter ties are not provided at the top of the rafter support walls, the ridge formed by these rafters shall be supported by a girder conforming to Clause 24.8.8. Rafter ties shall be spaced not more than 1219 mm (4 feet) on center.

Rafter tie connections shall be based on the equivalent rafter spacing in Table 24.8.7.3.1.

24.8.7.4 Notches and holes.

Notching at the ends of rafters or ceiling joists shall not exceed one-fourth the depth. Notches in the top or bottom of the rafter or ceiling joist shall not exceed one-sixth the depth and shall not be located in the middle one-third of the span, except that a notch not more than one-third of the depth is permitted in the top of the rafter or ceiling joist not further from the face of the support than the depth of the member. Holes bored in rafters or ceiling joists shall not be within 51 mm (2 inches) of the top and bottom and their diameter shall not exceed one-third the depth of the member.

24.8.7.5 Wind uplift.

The roof construction shall have rafter and truss ties to the wall below. Resultant uplift loads shall be transferred to the foundation using a continuous load path. The rafter or truss to wall connection shall comply with Tables 24.4.10.1 and 24.8.7.5.

### TABLE 24.8.7.5 REQUIRED RATING OF APPROVED UPLIFT CONNECTORS (pounds)

<table>
<thead>
<tr>
<th>NOMINAL DESIGN WIND SPEED, ( V_{asd} )</th>
<th>ROOF SPAN (feet)</th>
<th>OVERHANGS (pounds/feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>90</td>
<td>-91</td>
<td>-151</td>
</tr>
<tr>
<td>100</td>
<td>-131</td>
<td>-281</td>
</tr>
<tr>
<td>110</td>
<td>-175</td>
<td>-392</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 1.61 km/hr, 1 pound = 0.454 Kg, 1 pound/foot = 14.5939 N/m.
a. The uplift connection requirements are based on a 30-foot mean roof height located in Exposure B. For Exposure C or D and for other mean roof heights, multiply the loads by the following adjustment coefficients:

<table>
<thead>
<tr>
<th>Mean Roof Height (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPOSURE</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
</tbody>
</table>

b. The uplift connection requirements are based on the framing being spaced 24 inches on center. Multiply by 0.67 for framing spaced 16 inches on center and multiply by 0.5 for framing spaced 12 inches on center.
c. The uplift connection requirements include an allowance for 10 pounds of dead load.
d. The uplift connection requirements do not account for the effects of overhangs. The magnitude of the loads shall be increased by adding the overhang loads found in the table. The overhang loads are based on framing spaced 24 inches on center. The overhang loads given shall be multiplied by the overhang projection and added to the roof uplift value in the table.
e. The uplift connection requirements are based on wind loading on end zones as defined in Figure 28.5-1 of ASCE 7. Connection loads for connections located a distance of 20 percent of the least horizontal dimension of the building from the corner of the building are permitted to be reduced by multiplying the table connection value by 0.7 and multiplying the overhang load by 0.8.
f. For wall-to-wall and wall-to-foundation connections, the capacity of the uplift connector is permitted to be reduced by 100 pounds for each full wall above. (For example, if a 500-pound rated connector is used on the roof framing, a 400-pound rated connector is permitted at the next floor level down).
g. Interpolation is permitted for intermediate values of V ASD and roof spans.
h. The rated capacity of approved tie-down devices is permitted to include up to a 60-percent increase for wind effects where allowed by material specifications.
i. V ASD shall be determined in accordance with Clause 1609.3.1.

24.8.7.6 Framing around openings.
Trimmer and header rafters shall be doubled, or of timber of equivalent cross clause, where the span of the header exceeds 1219 mm (4 feet). The ends of header rafters that are more than 1829 mm (6 feet) in length shall be supported by framing anchors or rafter hangers unless bearing on a beam, partition or wall.

2308.7.6.1 Openings in roof diaphragms in Seismic Design Categories B, C, D and E.
In buildings classified as Seismic Design Category B, C, D or E. openings in horizontal diaphragms with a dimension that is greater than 1219 mm (4 feet) shall be constructed with metal ties and blocking in accordance with this clause and Figure 2308.4.1(1). Metal ties shall be not less than 0.058 inch [1.47 mm (16 galvanized gage)] in thickness by 1/2 inches (38 mm) in width and shall have a yield stress not less than 227 Mpa (33,000 psi). Blocking shall extend not less than the dimension of the opening in the direction of the tie and blocking. Ties shall be attached to blocking in accordance with the manufacturer's instructions but with not less than eight 16d common nails on each side of the header-joist interclause.

24.8.7.7 Purlins.
Purlins to support roof loads are permitted to be installed to reduce the span of rafters within allowable limits and shall be supported by struts to bearing walls. The maximum span of 51 mm by 102 mm (2-inch by 4-inch) purlins shall be 1219 mm (4 feet). The maximum span of the 51 mm by 152 mm (2-inch by 6-inch) purlin shall be 1829 mm (6 feet), but the purlin shall not be smaller than the supported rafter. Struts shall be not less than 51 mm by 102 mm (2-inch by 4-inch) members. The unbraced length of struts shall not exceed 2438 mm (8 feet) and the slope of the struts shall be not less than 45 degrees (0.79 rad) from the horizontal.

24.8.7.8 Blocking.
Roof rafters and ceiling joists shall be supported laterally to prevent rotation and lateral displacement in accordance with Clause
24.8.4.6 and connected to braced wall lines in accordance with Clause 24.8.6.7.2.

24.8.7.9 Engineered wood products.

Prefabricated wood I-joists, structural glued-laminated timber and structural composite timber shall not be notched or drilled except where permitted by the manufacturer’s recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

24.8.7.10 Roof sheathing.

Roof sheathing shall be in accordance with Tables 24.4.8(3) and 24.4.8(5) for wood structural panels, and Tables 24.4.8(1) and 24.4.8(2) for timber and shall comply with Clause 24.4.8.2.

24.8.7.11 Joints.

Joints in timber sheathing shall occur over supports unless approved end-matched timber is used, in which case each piece shall bear on not fewer than two supports.

24.8.7.12 Roof planking.

Planking shall be designed in accordance with the general provisions of this Code.

In lieu of such design, 51 mm (2-inch) tongue-and groove planking is permitted in accordance with Table 24.8.7.12. Joints in such planking are permitted to be randomly spaced, provided that the system is applied to not less than three continuous spans, planks are center matched and end matched or splined, each plank bears on one support or more, and joints are separated by not less than 610 mm (24 inches) in adjacent pieces.

### TABLE 24.8.7.12 ALLOWABLE SPANS FOR 2-INCH TONGUE-AND-GROOVE DECKING

<table>
<thead>
<tr>
<th>SPAN a (feet)</th>
<th>LIVE LOAD (pounds per square foot)</th>
<th>DEFLECTION LIMIT</th>
<th>BENDING STRESS (f) (pounds per square inch)</th>
<th>MODULUS OF ELASTICITY (E) (pounds per square inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roofs</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>1/240</td>
<td>160</td>
<td>242,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/360</td>
<td></td>
<td>305,000</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>1/240</td>
<td>210</td>
<td>256,000</td>
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<tr>
<td></td>
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<td>1/360</td>
<td></td>
<td>384,000</td>
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<td>40</td>
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<td>270</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>1/360</td>
<td></td>
<td>512,000</td>
</tr>
<tr>
<td>4.5</td>
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<td>200</td>
<td>242,000</td>
</tr>
<tr>
<td></td>
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<td>305,000</td>
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<td>270</td>
<td>363,000</td>
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<td>1/360</td>
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<td>405,000</td>
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<td>1/240</td>
<td>350</td>
<td>484,000</td>
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<td></td>
<td></td>
<td>1/360</td>
<td></td>
<td>1,000,000</td>
</tr>
<tr>
<td>5.5</td>
<td>20</td>
<td>1/240</td>
<td>300</td>
<td>442,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/360</td>
<td></td>
<td>660,000</td>
</tr>
<tr>
<td>SPAN a (feet)</td>
<td>LIVE LOAD (pounds per square foot)</td>
<td>DEFLECTION LIMIT</td>
<td>BENDING STRESS (f) (pounds per square inch)</td>
<td>MODULUS OF ELASTICITY (E) (pounds per square inch)</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------</td>
<td>------------------</td>
<td>------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1/240 1/360</td>
<td>400</td>
<td>662,000 998,000</td>
<td></td>
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<td>1/240 1/360</td>
<td>360</td>
<td>575,000 862,000</td>
<td></td>
</tr>
<tr>
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<td>1/240 1/360</td>
<td>480</td>
<td>862,000 1,295,000</td>
<td></td>
</tr>
<tr>
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<td>1/240 1/360</td>
<td>600</td>
<td>1,150,000 1,730,000</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td>20 1/240 1/360</td>
<td>420</td>
<td>595,000 892,000</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1/240 1/360</td>
<td>560</td>
<td>892,000 1,340,000</td>
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</tr>
<tr>
<td>40</td>
<td>1/240 1/360</td>
<td>700</td>
<td>1,190,000 1,730,000</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>20 1/240 1/360</td>
<td>490</td>
<td>910,000 1,360,000</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1/240 1/360</td>
<td>650</td>
<td>1,370,000 2,000,000</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>1/240 1/360</td>
<td>810</td>
<td>1,820,000 2,725,000</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>20 1/240 1/360</td>
<td>560</td>
<td>1,125,000 1,685,000</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1/240 1/360</td>
<td>750</td>
<td>1,685,000 2,530,000</td>
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</tr>
<tr>
<td>40</td>
<td>1/240 1/360</td>
<td>930</td>
<td>2,250,000 3,380,000</td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>20 1/240 1/360</td>
<td>640</td>
<td>1,360,000 2,040,000</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1/240 1/360</td>
<td>850</td>
<td>2,040,000 3,060,000</td>
<td></td>
</tr>
</tbody>
</table>

(continued)

TABLE 24.8.7.12—continued ALLOWABLE SPANS FOR 2-INCH TONGUE-AND-GROOVE DECKING

Floors
| 4  | 4.5 | 5.0 | 40 | 1/360 | 840 | 950 | 1,060 | 1,000,000 | 1,300,000 | 1,600,000 |

**Note:** For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kN/m², 1 pound per square inch = 0.00689 N/mm².

a. Spans are based on simple beam action with 10 pounds per square foot dead load and provisions for a 300-pound concentrated load on a 12-inch width of decking. Random layup is permitted in accordance with the provisions of Clause 24.8.7.12. Timber thickness is $\frac{1}{2}$ inches nominal.
24.8.7.13 Wood trusses.
Wood trusses shall be designed in accordance with Clause 24.3.4. Connection to braced wall lines shall be in accordance with Clause 24.8.6.7.2.

24.8.7.14 Attic ventilation.
For attic ventilation, see part 13

24.8.8 Design of elements.
Combining of engineered elements or systems and conventionally specified elements or systems shall be permitted subject to the limits of Clauses 24.8.8.1 and 24.8.8.2.

24.8.8.1 Elements exceeding limitations of conventional construction.
Where a building of otherwise conventional construction contains structural elements exceeding the limits of Clause 24.8.2, these elements and the supporting load path shall be designed in accordance with accepted engineering practice and the provisions of this Code.

24.8.8.2 Structural elements or systems not described herein.
Where a building of otherwise conventional construction contains structural elements or systems not described in Clause 24.8, these elements or systems shall be designed in accordance with accepted engineering practice and the provisions of this Code. The extent of such design need only demonstrate compliance of the nonconventional elements with other applicable provisions of this Code and shall be compatible with the performance of the conventionally framed system.

24.9 NEW OR ALTERNATIVE MATERIALS

24.9.1 The provisions of this part do not preclude the use of any material not specifically prescribed. Any such material must be referenced to the Ghana Standards Authority for approval provided it is shown to be satisfactory for the purpose intended and at least the equivalent of that in this Part in quality, strength, effectiveness, fire resistance, durability, safety, maintenance and compatibility.

24.9.1.1 Approval in writing shall be obtained by the owner or his agent before any new material is used. The Authority having jurisdiction shall base such approval on the principle set forth in Clause 9.3.1 and shall require that tests be carried out Clause 9.6 or sufficient evidence or proof be submitted, at the expense of the owner or his agent, to substantiate any claim for the proposed material.

24.9.2 Bamboo as a Building Material
Bamboo as a building material can be used in construction as scaffolding, small bridges, and structures and for housing. It has high compressive strength and low weight. It has high tensile strength; high fire resisting properties and can withstand temperatures up to 4000℃. It has good elastic features and does well in earthquake prone areas.

24.9.2.1 Preservation
Bamboo shall be treated against insects and rot before its put to use in construction. A mixture of borax and boric acid shall be used. Treatment by boiling cut bamboo to remove the starch that bore insects.

24.9.2.2 Structural Use of Bamboo
Bamboo intended to be used for structural purposes shall be tested by an approved testing agency to meet the requirements of the relevant clauses of this Code and any other relevant international requirements for structural strength, fire resistance, durability and safety.

24.9.2.3 Housing and Small Buildings;
Bamboo used in this form shall meet all the requirements for wood. It can be used as solid culms, halved culms or as longitudinal split...
strips. It can be used in all parts of the housing construction except:

1. Fireplaces
2. Chimneys

24.9.2.4 Foundations

Bamboo shall not be used for foundations unless adequately treated with preservatives and shown to be adequate by a test report from an approved testing agency. The types of bamboo foundations are:

1. Bamboo in direct contact with ground: for strength and stability, large diameter and thick walled clauses of bamboo with closely spaced nodes shall be used. Where these are not available, smaller clauses shall be tied together.
2. Bamboo on rock or preformed concrete footings: where bamboo is used as bearings, it shall be placed out of ground contact on footings of preformed concrete or rocks. The largest and structurally strong clauses shall be used.
3. Composite bamboo/concrete columns: an extension of concrete by a bamboo post shall be done by using a plastic tube of the same diameter as the bamboo.
4. Bamboo piles (wattle and daub): treated split bamboo piles shall be filled with fibrous strands (coconut, palm nuts, etc.) and the clauses tied with wire. The area can be finished with masonry mortar, etc.
5. Bamboo plastic composites: bamboo fibres used as raw materials and compounded with plastic as the core of the flooring. This has high water impermeability and dimensional stability.

24.9.2.6 Walls

Bamboo posts and beams shall constitute part or structural framework that is capable of carrying its weight and other imposed loads. An infill material suitable for protecting the bamboos from rain, wind, etc. and to offer privacy, and provide in plane bracing to ensure stability for the structure shall be required and used.

24.9.2.7 Roofing

The bamboo structure of a roof shall comprise purlins, rafters and trusses among others. Forms of bamboo roofing shall be in accordance with the following:

1. Purlins and beams supported on perimeter posts. Halved culms laid convex side down, edge to edge, spanning from the ridge to the eaves. A second layer, convex side up shall be laid to cover the joints.
2. Corrugated sheets made out of bamboo dipped in resin, dried and heat pressed under pressure in specially made platens to give strong sheets shall be used.
3. A layer of bitumen is sandwiched between two mats of bamboo forming a semi rigid panel. The mats shall be fixed to rafters at 200mm centers and a bituminous or a PVC weather proof coating applied to the finished roof.
4. Plastered bamboo: Cement based plaster with or without the addition of organic fibres shall be applied to bamboo roofs to get stronger roof coverings. Various forms of trusses can be adopted using bamboo culms of diameter ranging from 40-100mm.

24.9.3 Scaffolding

Lashed joints and any suitable joints shall be used. The extensions shall be carried out by lashing the ends together with several ties. The ties shall be arranged in such a way that loads acting vertically downwards wedges the nodes in the lashing. The vertical and horizontal members used for scaffolding shall be joined using lashing and any approved methods.

24.9.4 Rattan

The use of rattan shall be permitted. This shall comply with the relevant clauses of this Code and GS 195.

24.9.5 METHODS OF TEST

24.9.5.1 Every test of material required in this part or by the Authority having jurisdiction shall be carried out in accordance with standard methods of test issued by the Ghana Standards Authority. In the absence of methods of Tests where Ghana standards are not available, the tests shall conform to the methods of tests issued by the recognized authority. Laboratory tests shall be conducted by recognized laboratories acceptable to the Ghana Standards Authority.

24.9.5.1.1 The manufacturer/supplier shall ensure that materials conform to the requirements of the specifications of the Ghana Standard and if requested, shall supply a certificate to this effect to the purchaser or his representative.

24.9.5.1.2 When the certificate in Clause 24.9.5.1.1 are not available, the specimen of the material shall be tested and the cost thereof should be borne by the manufacturer/supplier if the material does not conform to the specification after such tests. If the material is found acceptable, the purchaser will bear the cost of such tests.
PART 25: GLASS AND GLAZING

User notes:

About this part: Part 25 establishes regulations for glass and glazing used in buildings and structures. Engineering and design requirements are included in the part for glazing that is subjected to wind load. Another concern of this part is glass and glazing used in areas where it is likely to be impacted by the occupants. Clause 25.6 identifies hazardous locations where glazing must either be safety glazing or protected to prevent impacts by occupants. Safety glazing must meet stringent standards and be appropriately marked or identified. Additional requirements are provided for glass and glazing in guards, handrails, elevator hoistways and elevator cars, as well as in athletic facilities.

25.1 GENERAL

25.1.1 Scope.

The provisions of this part shall govern the materials, design, construction and quality of glass, light-transmitting ceramic and light-transmitting plastic panels for exterior and interior use in both vertical and sloped applications in buildings and structures.

25.2 GLAZING REPLACEMENT

25.2.1 General.

The installation of replacement glass shall be as required for new installations.

25.3 GENERAL REQUIREMENTS FOR GLASS

25.3.1 Identification.

Each pane shall bear the manufacturer’s mark designating the type and thickness of the glass or glazing material. The identification shall not be omitted unless approved and an affidavit is furnished by the glazing contractor certifying that each light is glazed in accordance with approved construction documents that comply with the provisions of this part. Safety glazing shall be identified in accordance with Clause 25.6.3. Each pane of tempered glass, except tempered spandrel glass, shall be permanently identified by the manufacturer. The identification mark shall be acid etched, sand blasted, ceramic fired, laser etched, embossed or of a type that, once applied, cannot be removed without being destroyed. Tempered spandrel glass shall be provided with a removable paper marking by the manufacturer.

25.3.2 Glass supports.

Where one or more sides of any pane of glass are not firmly supported, or are subjected to unusual load conditions, detailed construction documents, detailed shop drawings and analysis or test data ensuring safe performance for the specific installation shall be prepared by a registered design professional.

25.3.3 Framing.

To be considered firmly supported, the framing members for each individual pane of glass shall be designed so the deflection of the edge of the glass perpendicular to the glass pane shall not exceed \( \frac{1}{175} \) of the glass edge length or 19.1 mm (\( \frac{3}{8} \) inch), whichever is less, when subjected to the larger of the positive or negative load where loads are combined as specified in this Code.

25.3.4 Interior glazed areas.

Where interior glazing is installed adjacent to a walking surface, the differential deflection of two adjacent unsupported edges shall be not greater than the thickness of the panels when a force of 50 pounds per linear foot (plf) (730 N/m) is applied horizontally to one panel at any point up to 1067 mm (42 inches) above the walking surface.

25.3.5 Louvered windows or jalousies.

Float, wired and patterned glass in louvered windows and jalousies shall be not thinner than nominal 4.8 mm (\( \frac{3}{16} \) inch) and not longer than 1219 mm (48 inches). Exposed glass edges shall be smooth.

Wired glass with wire exposed on longitudinal edges shall not be used in louvered windows or jalousies.

Where other glass types are used, the design shall be submitted to the Head of Works department for approval.

25.4 WIND, SEISMIC AND DEAD LOADS ON GLASS

25.4.1 Vertical glass.

Glass sloped 15 degrees (0.26 rad) or less from...
vertical in windows, curtain and window walls, doors and other exterior applications shall be designed to resist the wind loads due to basic design wind speed, $V$, in this Code for components and cladding. Glass in glazed curtain walls, glazed storefronts and glazed partitions shall meet the seismic requirements of ASCE 7. The load resistance of glass under uniform load shall be determined in accordance with ASTM E1300.

The design of vertical glazing shall be based on Equation 25-1.

$$0.6F_{gw} \leq F_{ga} \quad \text{(Equation 25-1)}$$

Where:

- $F_{gw}$ = Wind load on the glass due to basic design wind speed, $V$, computed in accordance with this code.
- $F_{ga}$ = Short duration load on the glass as determined in accordance with ASTM E1300

25.4.2 Sloped glass.
Glass sloped more than 15 degrees (0.26 rad) from vertical in skylights, sunrooms, sloped roofs and other exterior applications shall be designed to resist the most critical combinations of loads determined by Equations 25-2, 25-3 and 25-4.

$$F = 0.6W_o - D \quad \text{(Equation 25-2)}$$

$$F = 0.6W_i + D + 0.5S \quad \text{(Equation 25-3)}$$

$$F = 0.3W_i + D + S \quad \text{(Equation 25-4)}$$

where:

- $D$ = Glass dead load psf (kN/m$^2$).
  For glass sloped 30 degrees (0.52 rad) or less from horizontal,
  $$= 13 t \quad \text{(For SI: 0.0245 t ).}$$
  For glass sloped more than 30 degrees (0.52 rad) from horizontal,
  $$= 13 t \cos \theta \quad \text{(For SI: 0.0245 t \cos \theta).}$$

- $W_i$ = Inward wind force, psf (kN/m$^2$) due to basic design wind speed, $V$, as calculated in this Code
- $W_o$ = Outward wind force, psf (kN/m$^2$) due to basic design wind speed, $V$, as calculated in this Code
- $S$ = Snow load, psf (kN/m$^2$) as determined in Clause 17.8
- $t$ = Total glass thickness, inches (mm) of glass panes and plies.
- $g$ = Total load, psf (kN/m$^2$) on glass.
- $\theta$ = Angle of slope from horizontal.

Exception: The performance grade rating of unit skylights and tubular daylighting devices shall be determined in accordance with Clause 25.5.5.

The design of sloped glazing shall be based on Equation 25-5.

$$F \leq F_{ga} \quad \text{(Equation 24-5)}$$

where:

- $F$ = Total load on the glass as determined by Equations 25-2, 25-3 and 25-4.
- $F_{ga}$ = Short duration load resistance of the glass as determined in accordance with ASTM E1300 for Equations 25-2 and 25-3; or the long duration load resistance of the glass as determined in accordance with ASTM E1300 for
25.4.3 Wired, patterned and sandblasted glass.

25.4.3.1 Vertical wired glass.

Wired glass sloped 15 degrees (0.26 rad) or less from vertical in windows, curtain and window walls, doors and other exterior applications shall be designed to resist the wind loads in this Code for components and cladding according to the following equation:

\[ 0.6F_{gw} < 0.5F_{ge} \]  
(Equation 25-6)

where:

\[ F_{gw} = \text{Wind load on the glass due to basic design wind speed, } V, \text{ computed in accordance with this Code} \]

\[ F_{ge} = \text{Nonfactored load from ASTM E1300 using a thickness designation for monolithic glass that is not greater than the thickness of wired glass.} \]

25.4.3.2 Sloped wired glass.

Wired glass sloped more than 15 degrees (0.26 rad) from vertical in skylights, sunspaces, sloped roofs and other exterior applications shall be designed to resist the most critical of the combinations of loads from Clause 25.4.2. For Equations 25-2 and 25-3:

\[ F_{gw} < 0.5F_{ge} \]  
(Equation 25-7)

For Equations 25-2 and 25-3:

\[ F_{gw} < 0.3F_{ge} \]  
(Equation 25-8)

where:

\[ F_{gw} = \text{Wind load on the glass due to basic design wind speed, } V, \text{ computed in accordance with this Code} \]

\[ F_{ge} = \text{Nonfactored load in accordance with ASTM E1300.} \]

25.4.3.3 Vertical patterned glass.

Patterned glass sloped 15 degrees (0.26 rad) or less from vertical in windows, curtain and window walls, doors and other exterior applications shall be designed to resist the wind loads in this Code for components and cladding according to Equation 25-9.

\[ F_{gw} < 1.0F_{ge} \]  
(Equation 25-9)

where:

\[ F_{gw} = \text{Wind load on the glass due to basic design wind speed, } V, \text{ computed in accordance with this Code} \]

\[ F_{ge} = \text{Nonfactored load in accordance with ASTM E1300.} \]

The value for patterned glass shall be based on the thinnest part of the glass. Interpolation between nonfactored load charts in ASTM E1300 shall be permitted.

25.4.3.4 Sloped patterned glass.

Patterned glass sloped more than 15 degrees (0.26 rad) from vertical in skylights, sunspaces, sloped roofs and other exterior applications shall be designed to resist the most critical of the combinations of loads from Clause 25.4.2. For Equations 25-2 and 25-3:

\[ F_{gw} < 1.0F_{ge} \]  
(Equation 25-10)

For Equation 25-4:

\[ F_{gw} < 0.6F_{ge} \]  
(Equation 25-11)

where
\[ F_g = \text{Total load on the glass as determined by Equations 25-2, 25-3 and 25-4.} \]

\[ F_{ge} = \text{Nonfactored load in accordance with ASTM E1300. The value for patterned glass shall be based on the thinnest part of the glass. Interpolation between the nonfactored load charts in ASTM E1300 shall be permitted.} \]

**25.3.5 Vertical sandblasted glass.**
Sandblasted glass sloped 15 degrees (0.26 rad) or less from vertical in windows, curtain and window walls, doors, and other exterior applications shall be designed to resist the wind loads in this Code for components and cladding according to Equation 25-12.

\[ 0.6F_{gw} < 0.5F_{ge} \quad (\text{Equation 25-12}) \]

where:

\[ F_g = \text{Wind load on the glass due to basic design wind speed, } V, \text{ computed in accordance with this code.} \]

\[ F_{ge} = \text{Nonfactored load in accordance with ASTM E1300. The value for sandblasted glass is for moderate levels of sandblasting.} \]

**25.4.4 Other designs.**
For designs outside the scope of this clause, an analysis or test data for the specific installation shall be prepared by a registered design professional.

**25.5 SLOPED GLAZING AND SKYLIGHTS**

**25.5.1 Scope.**
This clause applies to the installation of glass and other transparent, translucent or opaque glazing material installed at a slope more than 15 degrees (0.26 rad) from the vertical plane, including glazing materials in skylights, roofs and sloped walls.

**25.5.2 Allowable glazing materials and limitations.**
Sloped glazing shall be any of the following materials, subject to the listed limitations.

1. For monolithic glazing systems, the glazing material of the single light or layer shall be laminated glass with a minimum 0.76 mm (30-mil) polyvinyl butyral (or equivalent) interlayer, wired glass, light-transmitting plastic materials meeting the requirements of Clause 27.7, heat-strengthened glass or fully tempered glass.

2. For multiple-layer glazing systems, each light or layer shall consist of any of the glazing materials specified in Item 1.

Annealed glass is permitted to be used as specified in Exceptions 2 and 3 of Clause 245.3.

For additional requirements for plastic skylights, see Clause 27.10. (refer to plastics)
Glass-block construction shall conform to the requirements of Clause 22.10.1 (refer to glass-block under masonry)

**25.5.3 Screening.**
Where used in monolithic glazing systems, heat-strengthened and fully tempered glass shall have screens installed below the glazing material. The screens and their fastenings shall be: capable of supporting twice the weight of the glazing; firmly and substantially fastened to the framing members; and installed within 102 mm (4 inches) of the glass. The screens shall be constructed of a noncombustible material not thinner than No. 12 B&S gage (0.0808 inch) with mesh not larger than 25 mm by 25 mm (1 inch by 1 inch). In a corrosive atmosphere, structurally equivalent noncorrosive screen materials shall be used. Heat-strengthened glass, fully tempered glass and wired glass, where used in multiple-layer glazing systems as the bottom glass layer over the walking surface, shall be equipped with screening that conforms to the requirements for monolithic glazing systems.

**Exception:** In monolithic and multiple-layer sloped glazing systems, the following applies:
1. Fully tempered glass installed without protective screens where glazed between intervening floors at a slope of 30 degrees (0.52 rad) or less from the vertical plane shall have the highest point of the glass 3048 mm (10 feet) or less above the walking surface.

2. Screens are not required below any glazing material, including annealed glass, where the walking surface below the glazing material is permanently protected from the risk of falling glass or the area below the glazing material is not a walking surface.

3. Any glazing material, including annealed glass, is permitted to be installed without screens in the sloped glazing systems of commercial or detached noncombustible greenhouses used exclusively for growing plants and not open to the public, provided that the height of the greenhouse at the ridge does not exceed 9144 mm (30 feet) above grade.

4. Screens shall not be required in individual dwelling units in Groups R-2, R-3 and R-4 where fully tempered glass is used as single glazing or as both panes in an insulating glass unit, and the following conditions are met:

   4.1. Each pane of the glass is 1.5 m² (16 square feet) or less in area.

   4.2. The highest point of the glass is 3658 mm (12 feet) or less above any walking surface or other accessible area.

   4.3. The glass thickness is 4.8 mm (3/16 inch) or less.

5. Screens shall not be required for laminated glass with a 0.38 mm (15-mil) polyvinyl butyral (or equivalent) interlayer used in individual dwelling units in Groups R-2, R-3 and R-4 within the following limits:

   5.1. Each pane of glass is 1.5 m² (16 square feet) or less in area.

   5.2. The highest point of the glass is 3658 mm (12 feet) or less above a walking surface or other accessible area.

25.5.4 Framing.

In Type I construction, sloped glazing and skylight frames shall be constructed of noncombustible materials. In structures where acid fumes deleterious to metal are incidental to the use of the buildings, approved pressure-treated wood or other approved noncorrosive materials are permitted to be used for sash and frames. Framing supporting sloped glazing and skylights shall be designed to resist the tributary roof loads in Part 17. Skylights set at an angle of less than 45 degrees (0.79 rad) from the horizontal plane shall be mounted not less than 102 mm (4 inches) above the plane of the roof on a curb constructed as required for the frame. Skylights shall not be installed in the plane of the roof where the roof pitch is less than 45 degrees (0.79 rad) from the horizontal.

Exception: Installation of a skylight without a curb shall be permitted on roofs with a minimum slope of 14 degrees (three units vertical in 12 units horizontal) in Group R-3 occupancies. Unit skylights installed in a roof with a pitch flatter than 14 degrees (0.25 rad) shall be mounted not less than 102 mm (4 inches) above the plane of the roof on a curb constructed as required for the frame unless otherwise specified in the manufacturer’s installation instructions.

25.5.5 Unit skylights and tubular daylighting devices.

Unit skylights and tubular daylighting devices shall be tested and labeled as complying with AAMA/WDMA/CSA 101/I.S./A440. The label shall state the name of the manufacturer, the approved labeling agency, the product designation and the performance grade rating as
specified in AAMA/WDMA/CSA 101/1.S.2/A440. Where the product manufacturer has chosen to have the performance grade of the skylight rated separately for positive and negative design pressure, then the label shall state both performance grade ratings as specified in AAMA/WDMA/CSA 101/1.S.2/A440 and the skylight shall comply with Clause 25.5.5.2. Where the skylight is not rated separately for positive and negative pressure, then the performance grade rating shown on the label shall be the performance grade rating determined in accordance with AAMA/WDMA/CSA 101/1.S.2/A440 for both positive and negative design pressure and the skylight shall conform to Clause 25.5.5.1.

25.5.5.1 Skylights rated for the same performance grade for both positive and negative design pressure.
The design of skylights shall be based on Equation 25-13.

\[
F_g \leq PG \quad \text{(Equation 25-13)}
\]

where:

- \(F_g\) = Maximum load on the skylight determined from Equations 25-2 through 25-4 in Clause 25.4.2.
- \(PG\) = Performance grade rating of the skylight.

25.5.5.2 Skylights rated for separate performance grades for positive and negative design pressure.
The design of skylights rated for performance grade for both positive and negative design pressures shall be based on Equations 25-14 and 25-15.

\[
F_{gi} \leq PG_{Pos} \quad \text{(Equation 25-14)}
\]

\[
F_{go} \leq PG_{Neg} \quad \text{(Equation 25-15)}
\]

where:

- \(PG_{Pos}\) = Performance grade rating of the skylight under positive design pressure;
- \(PG_{Neg}\) = Performance grade rating of the skylight under negative design pressure;
- \(F_{gi}\) and \(F_{go}\) are determined in accordance with the following:

For \(0.6W_o \geq D\),

\[
W_o = \text{Outward wind force, psf (kN/m}^2\text{) due to basic design wind speed, } V, \text{ as calculated in Clause 1609.}
\]

The dead weight of the glazing, psf \(D = 25.4.2\) for glass, or by the weight of the plastic, psf \(2(kN/m^2)\) for plastic glazing.

\[
F_{gi} = \text{Maximum load on the skylight determined from Equations 25-3 and 25-4 in Clause 25.4.2.}
\]

\[
F_{go} = \text{Maximum load on the skylight determined from Equation 25-2.}
\]

For \(0.6W_o < D\),
The outward wind force, psf \( W_o \) due to basic design wind speed, \( V \), as calculated in Clause 1609.

\[
W_o = \text{The outward wind force, psf (kN/m}^2\text{) due to basic design wind speed, } V, \text{ as calculated in Clause 1609.}
\]

The dead weight of the glazing, psf

\[
D = \text{The dead weight of the glazing, psf (kN/m}^2\text{) as determined in Clause 25.4.2 for glass, or by the weight of the plastic for plastic glazing.}
\]

Maximum load on the skylight determined from Equations 25-2 through 25-4 in Clause 25.4.2.

\[
F_{gi} = \text{Maximum load on the skylight determined from Equations 25-2 through 25-4 in Clause 25.4.2.}
\]

\[
F_{go} = F_{go} = 0
\]

25.6 SAFETY GLAZING

25.6.1 Human impact loads.

Individual glazed areas, including glass mirrors, in hazardous locations as defined in Clause 25.6.4 shall comply with Clauses 25.6.1.1 through 25.6.1.4.

**Exception:** Mirrors and other glass panels mounted or hung on a surface that provides a continuous backing support.

25.6.1.1 Impact test.

Except as provided in Clauses 25.6.1.2 through 25.6.1.4, all glazing shall pass the impact test requirements of Clause 25.6.2.

25.6.2 Impact test.

Where required by other clauses of this Code, glazing shall be tested in accordance with CPSC 16 CFR Part 1201. Glazing shall comply with the test criteria for Category II, unless otherwise indicated in Table 25.6.2(1).

**Exception:** Glazing not in doors or enclosures for hot tubs, whirlpools, saunas, steam rooms, bathtubs and showers shall be permitted to be tested in accordance with ANSI Z97.1. Glazing shall comply with the test criteria for Class A, unless otherwise indicated in Table 25.6.2(2).

<table>
<thead>
<tr>
<th>EXPOSED SURFACE AREA OF ONE SIDE OF ONE LITE</th>
<th>GLAZING IN STORM OR COMBINATION DOORS (Category class)</th>
<th>GLAZING IN DOORS (Category class)</th>
<th>GLAZED PANELS REGULATED BY CLAUSE 25.6.4.3 (Category class)</th>
<th>GLAZED PANELS REGULATED BY CLAUSE 25.6.4.2 (Category class)</th>
<th>DOORS AND ENCLOSURES REGULATED BY CLAUSE 25.6.4.5 (Category class)</th>
<th>SLIDING GLASS DOORS PATIO TYPE (Category class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 square feet or less</td>
<td>I</td>
<td>I</td>
<td>No requirement</td>
<td>I</td>
<td>II</td>
<td>II</td>
</tr>
</tbody>
</table>

TABLE 25.6.2(1) MINIMUM CATEGORY CLASSIFICATION OF GLAZING USING CPSC 16 CFR PART 1201
Note: For SI: 1 square foot = 0.0929 m².

### TABLE 25.6.2(2) MINIMUM CATEGORY CLASSIFICATION OF GLAZING USING ANSI Z97.1

<table>
<thead>
<tr>
<th>EXPOSED SURFACE AREA OF ONE SIDE OF ONE LITE</th>
<th>GLAZED PANELS REGULATED BY CLAUSE 25.6.4.3 (Category class)</th>
<th>GLAZED PANELS REGULATED BY CLAUSE 25.6.4.2 (Category class)</th>
<th>DOORS AND ENCLOSURES REGULATED BY CLAUSE 25.6.4.5(^a) (Category class)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 square feet or less</td>
<td>No requirement</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>More than 9 square feet</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

Note: For SI: square foot = 0.0929 m².

\(^a\) Use is only permitted by the exception to Clause 25.6.2.

#### 25.6.3 Identification of safety glazing.

Except as indicated in Clause 25.6.3.1, each pane of safety glazing installed in hazardous locations shall be identified by a manufacturer's designation specifying who applied the designation, the manufacturer or installer and the safety glazing standard with which it complies, as well as the information specified in Clause 25.3.1. The designation shall be acid etched, sand blasted, ceramic fired, laser etched, embossed or of a type that once applied, cannot be removed without being destroyed. A label meeting the requirements of this clause shall be permitted in lieu of the manufacturer's designation.

#### Exceptions:

1. For other than tempered glass, manufacturer's designations are not required, provided that the Head of Works department approves the use of a certificate, affidavit or other evidence confirming compliance with this Code.

2. Tempered spandrel glass is permitted to be identified by the manufacturer with a removable paper designation.

#### 25.6.3.1 Multipane assemblies.

Multipane glazed assemblies having individual panes not exceeding 1 square foot (0.09 m²) in exposed areas shall have one pane or more in the assembly marked as indicated in Clause 25.6.3. Other panes in the assembly shall be marked "CPSC 16 CFR Part 1201" or "ANSI Z97.1," as appropriate.

#### 25.6.4 Hazardous locations.

The locations specified in Clauses 25.6.4.1 through 25.6.4.7 shall be considered to be specific hazardous locations requiring safety glazing materials.

#### 25.6.4.1 Glazing in doors.

Glazing in all fixed and operable panels of swinging, sliding and bifold doors shall be considered to be a hazardous location.

#### Exceptions:
1. Glazed openings of a size through which a 76 mm (3-inch-diameter) sphere is unable to pass.
2. Decorative glazing.
3. Glazing materials used as curved glazed panels in revolving doors.

25.6.4.2 Glazing adjacent to doors.
Glazing in an individual fixed or operable panel adjacent to a door where the nearest vertical edge of the glazing is within a 610 mm (24-inch) arc of either vertical edge of the door in a closed position and where the bottom exposed edge of the glazing is less than 1524 mm (60 inches) above the walking surface shall be considered to be a hazardous location.

Exceptions:
1. Decorative glazing.
2. Where there is an intervening wall or other permanent barrier between the door and glazing.
3. Where access through the door is to a closet or storage area 914 mm (3 feet) or less in depth. Glazing in this application shall comply with Clause 25.6.4.3.
4. Glazing in walls on the latch side of and perpendicular to the plane of the door in a closed position in one- and two-family dwellings or within dwelling units in Group R-2.

25.6.4.3 Glazing in windows.
Glazing in an individual fixed or operable panel that meets all of the following conditions shall be considered to be a hazardous location:

1. The exposed area of an individual pane is greater than 0.84 m\(^2\) (9 square feet).
2. The bottom edge of the glazing is less than 457 mm (18 inches) above the floor.
3. The top edge of the glazing is greater than 914 mm (36 inches) above the floor.
4. One or more walking surface(s) are within 914 mm (36 inches), measured horizontally and in a straight line, of the plane of the glazing.

Exceptions:
1. Decorative glazing.
2. Where a horizontal rail is installed on the accessible side(s) of the glazing 864 to 965 mm (34 to 38 inches) above the walking surface. The rail shall be capable of withstanding a horizontal load of 730 N/m (50 pounds per linear foot) without contacting the glass and be not less than 38 mm (1 1/2 inches) in cross-axial height.
3. Outboard panes in insulating glass units or multiple glazing where the bottom exposed edge of the glass is 7620 mm (25 feet) or more above any grade, roof, walking surface or other horizontal or sloped (within 45 degrees of horizontal) (0.79 rad) surface adjacent to the glass exterior.

25.6.4.4 Glazing in guards and railings.
Glazing in guards and railings, including structural baluster panels and nonstructural in-fill panels, regardless of area or height above a walking surface shall be considered to be a hazardous location.

25.6.4.5 Glazing and wet surfaces.
Glazing in walls, enclosures or fences containing or facing hot tubs, spas, whirlpools, saunas, steam rooms, bathtubs, showers and indoor or outdoor swimming pools where the bottom
exposed edge of the glazing is less than 1524 mm (60 inches) measured vertically above any standing or walking surface shall be considered to be a hazardous location. This shall apply to single glazing and all panes in multiple glazing.

**Exception:** Glazing that is more than 1524 mm (60 inches), measured horizontally and in a straight line, from the water’s edge of a bathtub, hot tub, spa, whirlpool or swimming pool.

### 25.6.4.6 Glazing adjacent to stairways and ramps

Glazing where the bottom exposed edge of the glazing is less than 1524 mm (60 inches) above the plane of the adjacent walking surface of stairways, landings between flights of stairs and ramps shall be considered to be a hazardous location.

**Exceptions:**

1. The side of a stairway, landing or ramp that has a guard complying with the provisions of Clauses 1015 and 1607.8, and the plane of the glass is greater than 457 mm (18 inches) from the railing.

2. Glazing 914 mm (36 inches) or more measured horizontally from the walking surface.

### 25.6.4.7 Glazing adjacent to the bottom stairway landing

Glazing adjacent to the landing at the bottom of a stairway where the glazing is less than 1524 mm (60 inches) above the landing and within a 1524 mm (60-inch) horizontal arc that is less than 180 degrees (3.14 rad) from the bottom tread nosing shall be considered to be a hazardous location.

**Exception:** Glazing that is protected by a guard complying with Clauses 11.15 where the plane of the glass is greater than 457 mm (18 inches) from the guard.

### 25.6.5 Fire department access panels

Fire department glass access panels shall be of tempered glass. For insulating glass units, all panes shall be tempered glass.

### 25.7 GLASS IN HANDRAILS AND GUARDS

#### 25.7.1 Materials

Glass used in a handrail or a guard shall be laminated glass constructed of fully tempered or heat-strengthened glass and shall comply with Category II or CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1. Glazing in railing in-fill panels shall be of an approved safety glazing material that conforms to the provisions of Clause 25.6.1.1. For all glazing types, the minimum nominal thickness shall be 6.4 mm (1/4 inch).

**Exception:** Single fully tempered glass complying with Category II of CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1 shall be permitted to be used in handrails and guardrails where there is no walking surface beneath them or the walking surface is permanently protected from the risk of falling glass.

#### 25.7.1.1 Loads

The panels and their support system shall be designed to withstand the loads specified in Clause 1607.8(Structural design). Glass guard elements shall be designed using a factor of safety of four.

#### 25.7.1.2 Structural glass baluster panels

Guards with structural glass baluster panels shall be installed with an attached top rail or handrail. The top rail or handrail shall be supported by not fewer than three glass baluster panels, or shall be otherwise supported to remain in place should one glass baluster panel fail.

**Exception:** An attached top rail or handrail is not required where the glass baluster panels are laminated glass with two or more glass plies of equal thickness and of the same glass type. The panels shall be tested to remain in place as a barrier following impact or glass breakage in accordance with ASTM E2353.
25.7.1.3 Parking garages.
Glazing materials shall not be installed in handrails or guards in parking garages except for pedestrian areas not exposed to impact from vehicles.

25.8 GLAZING IN ATHLETIC FACILITIES
25.8.1 General.
Glazing in athletic facilities and similar uses subject to impact loads, which forms whole or partial wall clauses or which is used as a door or part of a door, shall comply with this clause.

25.8.2 Racquetball and squash courts.
25.8.2.1 Testing.
Test methods and loads for individual glazed areas in racquetball and squash courts subject to impact loads shall conform to those of CPSC 16 CFR Part 1201 or ANSI Z97.1 with impacts being applied at a height of 1499 mm (59 inches) above the playing surface to an actual or simulated glass wall installation with fixtures, fittings and methods of assembly identical to those used in practice.

Glass walls shall comply with the following conditions:

1. A glass wall in a racquetball or squash court, or similar use subject to impact loads, shall remain intact following a test impact.
2. The deflection of such walls shall be not greater than 38 mm (1 1/2 inches) at the point of impact for a drop height of 1219 mm (48 inches).

Glass doors shall comply with the following conditions:

1. Glass doors shall remain intact following a test impact at the prescribed height in the center of the door.
2. The relative deflection between the edge of a glass door and the adjacent wall shall not exceed the thickness of the wall plus 1/2 inch (12.7 mm) for a drop height of 48 inches (1219 mm).

25.8.3 Gymnasiums and basketball courts.
(Structures)
Glazing in multipurpose gymnasiums, basketball courts and similar athletic facilities subject to human impact loads shall comply with Category II of CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1.

25.9 GLASS IN WALKWAYS, ELEVATOR HOISTWAYS AND ELEVATOR CARS
25.9.1 Glass walkways.
Glass installed as a part of a floor/ceiling assembly as a walking surface and constructed with laminated glass shall comply with ASTM E2751 or with the load requirements specified in Part 16. Such assemblies shall comply with the fire-resistance rating and marking requirements of this Code where applicable.

25.9.2 Glass in elevator hoistway enclosures.
Glass in elevator hoistway enclosures and hoistway doors shall be laminated glass conforming to ANSI Z97.1 or CPSC 16 CFR Part 1201.

25.9.2.1 Fire-resistance-rated hoistways.
Glass installed in hoistways and hoistway doors where the hoistway is required to have a fire-resistance rating shall comply with Clause 8.16.

25.9.2.2 Glass hoistway doors.
The glass in glass hoistway doors shall be not less than 60 percent of the total visible door panel surface area as seen from the landing side.

25.9.3 Visions panels in elevator hoistway doors.
Glass in vision panels in elevator hoistway doors shall be permitted to be any transparent glazing material not less than 6.4 mm (1/4 inch) in thickness conforming to Class A in accordance with ANSI Z97.1 or Category II in accordance with CPSC 16 CFR Part 1201. The area of any
single vision panel shall be not less than 15 484 mm$^2$ (24 square inches) and the total area of one or more vision panels in any hoistway door shall be not more than 54 839 mm$^2$ (85 square inches).

25.9.4 Glass in elevator cars.
Glass in elevator cars shall be in accordance with this clause.

25.9.4.1 Glass types.
Glass in elevator car enclosures, glass elevator car doors and glass used for lining walls and ceilings of elevator cars shall be laminated glass conforming to Class A in accordance with ANSI Z97.1 or Category II in accordance with CPSC 16 CFR Part 1201.

Exception: Tempered glass shall be permitted to be used for lining walls and ceilings of elevator cars provided that:

1. The glass is bonded to a nonpolymeric coating, sheeting or film backing having a physical integrity to hold the fragments when the glass breaks.

2. The glass is not subjected to further treatment such as sandblasting; etching; heat treatment or painting that could alter the original properties of the glass.

3. The glass is tested to the acceptance criteria for laminated glass as specified for Class A in accordance with ANSI Z97.1 or Category II in accordance with CPSC 16 CFR Part 1201.

25.9.4.2 Surface area.
The glass in glass elevator car doors shall be not less than 60 percent of the total visible door panel surface area as seen from the car side of the doors.

PART 26: GYPSUM BOARD, GYPSUM PANEL PRODUCTS AND PLASTER

User notes:
About this part: Part 26 contains the provisions and referenced standards that regulate the design, construction and quality of gypsum board, gypsum panel products and plaster and, in addition, addresses reinforced gypsum concrete. These materials are some of the most commonly used interior and exterior finish materials in the building industry. This part primarily addresses quality-control-related issues with regard to material specifications and installation requirements. Most products are manufactured in accordance with industry standards. The Head of Works department or inspector needs to verify that the appropriate product is used and properly installed for the intended use and location. Proper design and installation of these materials are necessary to provide weather resistance and required fire protection for both structural and nonstructural building components.

26.1 GENERAL
26.1.1 Scope.
Provisions of this part shall govern the materials, design, construction and quality of gypsum board, gypsum panel products, lath, gypsum plaster, cement plaster and reinforced gypsum concrete.

26.1.2 Other materials.
Other approved wall or ceiling coverings shall be permitted to be installed in accordance with the
recommendations of the manufacturer and the conditions of approval.

26.2 PERFORMANCE

26.2.1 General.

Lathing, plastering and gypsum board and gypsum panel product construction shall be done in the manner and with the materials specified in this part and, where required for fire protection, shall comply with the provisions of Part 8.

26.3 INSPECTION

26.3.1 Inspection.

Lath, gypsum board and gypsum panel products shall be inspected in accordance with this Code.

26.4 VERTICAL AND HORIZONTAL ASSEMBLIES

26.4.1 Scope.

The following requirements shall be met where construction involves gypsum board, gypsum panel products or lath and plaster in vertical and horizontal assemblies.

26.4.1.1 Wood framing.

Wood supports for lath, gypsum board or gypsum panel products, as well as wood stripping or furring, shall be not less than 51 mm (2 inches) nominal thickness in the least dimension.

Exception: The minimum nominal dimension of wood furring strips installed over solid backing shall be not less than 25 mm by 51 mm (1 inch by 2 inches).

26.4.1.2 Studless partitions.

The minimum thickness of vertically erected studless solid plaster partitions of 9.5 mm (\(\frac{3}{8}\) inch) and 19.1 mm (\(\frac{3}{4}\) -inch) rib metal lath, 12.7 mm (\(\frac{1}{2}\) -inch-thick) gypsum lath, gypsum board or gypsum panel product shall be 51 mm (2 inches).

26.5 SHEAR WALL CONSTRUCTION

26.5.1 Resistance to shear (wood framing).

Wood-frame shear walls sheathed with gypsum board, gypsum panel products or lath and plaster shall be designed and constructed in accordance with Clause 24.6.3 and are permitted to resist wind and seismic loads. Walls resisting seismic loads shall be subject to the limitations in Clause 12.2.1 of ASCE 7.

26.5.2 Resistance to shear (steel framing).

Cold-formed steel-frame shear walls sheathed with gypsum board or gypsum panel products and constructed in accordance with the materials and provisions of this Code are permitted to resist wind and seismic loads. Walls resisting seismic loads shall be subject to the limitations in Clause 12.2.1 of ASCE 7.

26.6 GYPSUM BOARD AND GYPSUM PANEL PRODUCT MATERIALS

26.6.1 General.

Gypsum board, gypsum panel products and accessories shall be identified by the manufacturer’s designation to indicate compliance with the appropriate standards referenced in this clause and stored to protect such materials from the weather.

26.6.2 Standards.

Gypsum board and gypsum panel products shall conform to the appropriate standards listed in Table 26.6.2 and Part 36 and, where required for fire protection, shall conform to the provisions of Part 7.
### TABLE 26.6.2

**GYPSUM BOARD AND GYPSUM PANEL PRODUCTS MATERIALS AND ACCESSORIES**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessories for gypsum board</td>
<td>ASTM C1047</td>
</tr>
<tr>
<td>Adhesives for fastening gypsum board</td>
<td>ASTM C557</td>
</tr>
<tr>
<td>Cold-formed steel studs and track, structural</td>
<td>AISI S240</td>
</tr>
<tr>
<td>Cold-formed steel studs and track, nonstructural</td>
<td>AISI S220</td>
</tr>
<tr>
<td>Elastomeric joint sealants</td>
<td>ASTM C920</td>
</tr>
<tr>
<td>Expandable foam adhesives for fastening gypsum wallboard</td>
<td>ASTM D6464</td>
</tr>
<tr>
<td>Factory-laminated gypsum panel products</td>
<td>ASTM C1766</td>
</tr>
<tr>
<td>Fibre-reinforced gypsum panels</td>
<td>ASTM C1278</td>
</tr>
<tr>
<td>Glass mat gypsum backing panel</td>
<td>ASTM C1178</td>
</tr>
<tr>
<td>Glass mat gypsum panel 5</td>
<td>ASTM C1658</td>
</tr>
<tr>
<td>Glass mat gypsum substrate</td>
<td>ASTM C1177</td>
</tr>
<tr>
<td>Joint reinforcing tape and compound</td>
<td>ASTM C474; C475</td>
</tr>
<tr>
<td>Nails for gypsum boards</td>
<td>ASTM C514, F547, F1667</td>
</tr>
<tr>
<td>Steel screws</td>
<td>ASTM C954; C1002</td>
</tr>
<tr>
<td>Standard specification for gypsum board</td>
<td>ASTM C1396</td>
</tr>
<tr>
<td>Testing gypsum and gypsum products</td>
<td>ASTM C22; C472; C473</td>
</tr>
</tbody>
</table>

26.6.2.1 Other materials.

Metal suspension systems for acoustical and lay-in panel ceilings shall comply with ASTM C635 listed in Part 35 and Clause 13.5.6 of ASCE 7 for installation in high seismic areas.

### TABLE 26.7.2

**LATH, PLASTERING MATERIALS AND ACCESSORIES**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessories for gypsum veneer base</td>
<td>ASTM C1047</td>
</tr>
<tr>
<td>Blended cement</td>
<td>ASTM C595</td>
</tr>
<tr>
<td>Cold-formed steel studs and track, structural</td>
<td>AISI S240</td>
</tr>
<tr>
<td>Cold-formed steel studs and track, nonstructural</td>
<td>AISI S220</td>
</tr>
<tr>
<td>Exterior plaster bonding compounds</td>
<td>ASTM C932</td>
</tr>
<tr>
<td>Hydraulic cement</td>
<td>ASTM C1157; C1600</td>
</tr>
<tr>
<td>Gypsum casting and molding plaster</td>
<td>ASTM C59</td>
</tr>
<tr>
<td>Gypsum Keene’s cement</td>
<td>ASTM C61</td>
</tr>
<tr>
<td>Gypsum plaster</td>
<td>ASTM C28</td>
</tr>
<tr>
<td>Gypsum veneer plaster</td>
<td>ASTM C587</td>
</tr>
<tr>
<td>Interior bonding compounds, gypsum</td>
<td>ASTM C631</td>
</tr>
<tr>
<td>Lime plasters</td>
<td>ASTM C5; C206</td>
</tr>
<tr>
<td>Masonry cement</td>
<td>ASTM C91</td>
</tr>
<tr>
<td>Metal lath</td>
<td>ASTM C847</td>
</tr>
<tr>
<td>Plaster aggregates</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>ASTM C35; C897</td>
</tr>
<tr>
<td>Perlite</td>
<td>ASTM C35</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>ASTM C35</td>
</tr>
<tr>
<td>Plastic cement</td>
<td>ASTM C1328</td>
</tr>
<tr>
<td>Portland cement</td>
<td>ASTM C150</td>
</tr>
<tr>
<td>Steel screws</td>
<td>ASTM C1002; C954</td>
</tr>
<tr>
<td>Welded wire lath</td>
<td>ASTM C933</td>
</tr>
<tr>
<td>Woven wire plaster base</td>
<td>ASTM C1032</td>
</tr>
</tbody>
</table>

26.7 LATHING AND PLASTERING

26.7.1 General.

Lathing and plastering materials and accessories shall be marked by the manufacturer’s designation to indicate compliance with the appropriate standards referenced in this clause and stored in such a manner to protect them from the weather.

26.7.2 Standards.

Lathing and plastering materials shall conform to the standards listed in Table 26.7.2 and Part 36 and, where required for fire protection, shall conform to the provisions of Part 8.
26.8 GYPSUM CONSTRUCTION

26.8.1 General.

Gypsum board, gypsum panel products and gypsum plaster construction shall be of the materials listed in Tables 26.6.2 and 26.7.2. These materials shall be assembled and installed in compliance with the appropriate standards listed in Tables 26.8.1 and 26.11.1.1 and Part 36.

| TABLE 26.8.1 |
| INSTALLATION OF GYPSUM CONSTRUCTION |
| **MATERIAL** | **STANDARD** |
| Gypsum board and gypsum panel products | GA-216; ASTM C840 |
| Gypsum sheathing and gypsum panel products | ASTM C1280 |
| Gypsum veneer base | ASTM C844 |
| Interior lathing and furring | ASTM C841 |
| Steel framing for gypsum board and gypsum panel products | ASTM C754; C1007 |

26.8.2 Limitations.

Gypsum wallboard or gypsum plaster shall not be used in any exterior surface where such gypsum construction will be exposed directly to the weather. Gypsum wallboard shall not be used where there will be direct exposure to water or continuous high humidity conditions. Gypsum sheathing shall be installed on exterior surfaces in accordance with ASTM C1280.

26.8.2.1 Weather protection.

Gypsum wallboard, gypsum lath or gypsum plaster shall not be installed until weather protection for the installation is provided.

26.8.3 Single-ply application.

Edges and ends of gypsum board and gypsum panel products shall occur on the framing members, except those edges and ends that are perpendicular to the framing members. Edges and ends of gypsum board and gypsum panel products shall be in moderate contact except in concealed spaces where fire-resistance-rated construction, shear resistance or diaphragm action is not required.

26.8.3.1 Floating angles.

Fasteners at the top and bottom plates of vertical assemblies, or the edges and ends of horizontal assemblies perpendicular to supports, and at the wall line are permitted to be omitted except on shear resisting elements or fire-resistance-rated assemblies. Fasteners shall be applied in such a manner as not to fracture the face paper with the fastener head.

26.8.4 Adhesives.

Gypsum board and gypsum panel products secured to framing with adhesives in ceiling assemblies shall be attached using an approved fastening schedule. Expandable foam adhesives for fastening gypsum wallboard shall conform to ASTM D6464. Other adhesives for the installation of gypsum wallboard shall conform to ASTM C557.

26.8.5 Joint treatment.

Gypsum board and gypsum panel product fire-resistance-rated assemblies shall have joints and fasteners treated.

**Exception:** Joint and fastener treatment need not be provided where any of the following conditions occur:

1. Where the gypsum board or the gypsum panel product is to receive a decorative finish such as wood paneling, battens, acoustical finishes or any similar application that would be equivalent to joint treatment.

2. On single-layer systems where joints occur over wood framing members.

3. Square edge or tongue-and-groove edge gypsum board (V-edge), gypsum panel products, gypsum backing board or gypsum sheathing.

4. On multilayer systems where the joints of adjacent layers are offset.
5. Assemblies tested without joint treatment.

26.8.6 Horizontal gypsum board or gypsum panel product diaphragm ceilings.

Gypsum board or gypsum panel products shall be permitted to be used on wood joists to create a horizontal diaphragm ceiling in accordance with Table 26.8.6.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>THICKNESS OF MATERIAL (MINIMUM) (inches)</th>
<th>SPACING OF FRAMING MEMBERS (inches)</th>
<th>SHEAR VALUE(^a, b) (PLF OF CEILING)</th>
<th>MINIMUM FASTENER SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum board or gypsum panel product</td>
<td>1/2</td>
<td>16 o.c.</td>
<td>90</td>
<td>5d cooler or wallboard nail; 1 5/8-inch long; 0.086-inch shank; 15/64-inch head(^c)</td>
</tr>
<tr>
<td>Gypsum board or gypsum panel product</td>
<td>1/2</td>
<td>24 o.c.</td>
<td>70</td>
<td>5d cooler or wallboard nail; 1 5/8-inch long; 0.086-inch shank; 15/64-inch head(^c)</td>
</tr>
</tbody>
</table>

Note: For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.59 N/m.

a. Values are not cumulative with other horizontal diaphragm values and are for short-term wind or seismic loading. Values shall be reduced 25 percent for normal loading.

b. Values shall be reduced 50 percent in Seismic Design Categories D, E and F.

c. 1 1/4-inch, No. 6 Type S or W screws are permitted to be substituted for the listed nails.
26.8.6.1 Diaphragm proportions.
The maximum allowable diaphragm proportions shall be $1:1/2$ between shear resisting elements. Rotation or cantilever conditions shall not be permitted.

26.8.6.2 Installation.
Gypsum board or gypsum panel products used in a horizontal diaphragm ceiling shall be installed perpendicular to ceiling framing members. End joints of adjacent courses of gypsum board shall not occur on the same joist.

26.8.6.3 Blocking of perimeter edges.
Perimeter edges shall be blocked using a wood member not less than 51 mm by 152 mm (2-inch by 6-inch) nominal dimension. Blocking material shall be installed flat over the top plate of the wall to provide a nailing surface not less than 51 mm (2 inches) in width for the attachment of the gypsum board or gypsum panel product.

26.8.6.4 Fasteners.
Fasteners used for the attachment of gypsum board or gypsum panel products to a horizontal diaphragm ceiling shall be as defined in Table 26.8.6. Fasteners shall be spaced not more than 178 mm (7 inches) on center at all supports, including perimeter blocking, and not more than $9.5 \text{ mm (} 3/8 \text{ inch})$ from the edges and ends of the gypsum board or gypsum panel product.

26.8.6.5 Lateral force restrictions.
Gypsum board or gypsum panel products shall not be used in diaphragm ceilings to resist lateral forces imposed by masonry or concrete construction.

26.9 SHOWERS AND WATER CLOSETS
26.9.1 Wet areas.
Showers and public toilet walls shall conform to this Code.

26.9.2 Base for tile.
Materials used as a base for wall tile in tub and shower areas and wall and ceiling panels in shower areas shall be of materials listed in Table 26.9.2 and installed in accordance with the manufacturer’s recommendations. Water-resistant gypsum backing board shall be used as a base for tile in water closet compartment walls when installed in accordance with GA-216 or ASTM C840 and the manufacturer’s recommendations. Regular gypsum wallboard is permitted under tile or wall panels in other wall and ceiling areas when installed in accordance with GA-216 or ASTM C840.

### Table 26.9.2
**BACKERBOARD MATERIALS**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass mat gypsum backing panel</td>
<td>ASTM C1178</td>
</tr>
<tr>
<td>Nonasbestos fibre-cement backer board</td>
<td>ASTM C1288 or ISO 8336, Category C</td>
</tr>
<tr>
<td>Nonasbestos fibre-mat reinforced cementitious backer unit</td>
<td>ASTM C1325</td>
</tr>
</tbody>
</table>

26.9.3 Limitations.
Water-resistant gypsum backing board shall not be used in the following locations:

1. Over a vapour retarder in shower or bathtub compartments.
2. Where there will be direct exposure to water or in areas subject to continuous high humidity.

26.10 LATHING AND FURRING FOR CEMENT PLASTER (STUCCO)
26.10.1 General.
Exterior and interior cement plaster and lathing shall be done with the appropriate materials listed in Table 26.7.2 and Part 36.

26.10.2 Weather protection.
Materials shall be stored in such a manner as to protect them from the weather.

26.10.3 Installation.
Installation of these materials shall be in compliance with ASTM C926 and ASTM C1063.
26.10.4 Corrosion resistance.
Metal lath and lath attachments shall be of corrosion-resistant material.

26.10.5 Backing.
Backing or a lath shall provide sufficient rigidity to permit plaster applications.

26.10.5.1 Support of lath.
Where lath on vertical surfaces extends between rafters or other similar projecting members, solid backing shall be installed to provide support for lath and attachments.

26.10.5.2 Use of gypsum backing board.
Gypsum backing for cement plaster shall be in accordance with Clause 26.10.5.2.1 or 26.10.5.2.2.

26.10.5.2.1 Gypsum board as a backing board.
Gypsum lath or gypsum wallboard shall not be used as a backing for cement plaster.

Exception: Gypsum lath or gypsum wallboard is permitted, with a water-resistive barrier, as a backing for self-furred metal lath or self-furred wire fabric lath and cement plaster where either of the following conditions occur:

1. On horizontal supports of ceilings or roof soffits.
2. On interior walls.

26.10.5.2.2 Gypsum sheathing backing.
Gypsum sheathing is permitted as a backing for metal or wire fabric lath and cement plaster on walls. A water-resistant barrier shall be provided in accordance with Clause 26.10.6.

26.10.6 Water-resistive barriers.
Wire backing is not required under expanded metal lath or paperbacked wire fabric lath.

26.10.7 Preparation of masonry and concrete.
Surfaces shall be clean, free from efflorescence, sufficiently damp and rough for proper bond. If the surface is insufficiently rough, approved bonding agents or a Portland cement dash bond coat mixed in proportions of not more than two parts volume of sand to one part volume of Portland cement or plastic cement shall be applied. The dash bond coat shall be left undisturbed and shall be moist cured not less than 24 hours.

26.11 INTERIOR PLASTER
26.11.1 General.
Plastering gypsum plaster or cement plaster shall be not less than three coats where applied over metal lath or wire fabric lath and not less than two coats where applied over other bases permitted by this part.

Exception: Gypsum veneer plaster and cement plaster specifically designed and approved for one-coat applications.
26.11.1 Installation.
Installation of lathing and plaster materials shall conform to Table 26.11.1.1 and Clause 26.7.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement plaster</td>
<td>ASTM C926</td>
</tr>
<tr>
<td>Gypsum plaster</td>
<td>ASTM C842</td>
</tr>
<tr>
<td>Gypsum veneer plaster</td>
<td>ASTM C843</td>
</tr>
<tr>
<td>Interior lathing and furring</td>
<td>ASTM C841</td>
</tr>
<tr>
<td>(gypsum plaster)</td>
<td></td>
</tr>
<tr>
<td>Lathing and furring (cement</td>
<td>ASTM C1063</td>
</tr>
<tr>
<td>plaster)</td>
<td></td>
</tr>
<tr>
<td>Steel framing</td>
<td>ASTM C754;</td>
</tr>
<tr>
<td></td>
<td>C1007</td>
</tr>
</tbody>
</table>

26.11.2 Limitations.
Plaster shall not be applied directly to fibre insulation board. Cement plaster shall not be applied directly to gypsum lath or gypsum plaster except as specified in Clauses 26.10.5.1 and 26.10.5.2.

26.11.3 Grounds.
Where installed, grounds shall ensure the minimum thickness of plaster as set forth in ASTM C842 and ASTM C926. Plaster thickness shall be measured from the face of lath and other bases.

26.11.4 Interior masonry or concrete.
Condition of surfaces shall be as specified in Clause 26.10.7. Approved specially prepared gypsum plaster designed for application to concrete surfaces or approved acoustical plaster is permitted. The total thickness of base coat plaster applied to concrete ceilings shall be as set forth in ASTM C842 or ASTM C926. Should ceiling surfaces require more than the maximum thickness permitted in ASTM C842 or ASTM C926, metal lath or wire fabric lath shall be installed on such surfaces before plastering.

26.11.5 Wet areas.
Showers and public toilet walls shall conform to part 13. Where wood frame walls and partitions are covered on the interior with cement plaster or tile of similar material and are subject to water splash, the framing shall be protected with an approved moisture barrier.

26.12 EXTERIOR PLASTER

26.12.1 General.
Plastering with cement plaster shall be not less than three coats where applied over metal lath or wire fabric lath or gypsum board backing as specified in Clause 26.10.5 and shall be not less than two coats where applied over masonry or concrete. If the plaster surface is to be completely covered by veneer or other facing material, or is completely concealed by another wall, plaster application need only be two coats, provided that the total thickness is as set forth in ASTM C926.

26.12.1.1 On-grade floor slab.
On wood frame or steel stud construction with an on-grade concrete floor slab system, exterior plaster shall be applied in such a manner as to cover, but not to extend below, the lath and paper. The application of lath, paper and flashing or drip screeds shall comply with ASTM C1063.

26.12.1.2 Weep screeds.
A minimum 0.48 mm (0.019-inch) (No. 26 galvanized sheet gage), corrosion-resistant weep screed with a minimum vertical attachment flange of 89 mm (3 1/2 inches) shall be provided at or below the foundation plate line on exterior stud walls in accordance with ASTM C926. The weep screed shall be placed not less than 102 mm (4 inches) above the earth or 51 mm (2 inches) above paved areas and be of a type that will allow trapped water to drain to the exterior of the building. The water-resistant barrier shall lap the attachment flange. The exterior lath shall cover and terminate on the attachment flange of the weep screed.

26.12.2 Plasticity agents.
Only approved plasticity agents and approved amounts thereof shall be added to Portland cement or blended cements. Where plastic
cement or masonry cement is used, additional lime or plasticizers shall not be added. Hydrated lime or the equivalent amount of lime putty used as a plasticizer is permitted to be added to cement plaster or cement and lime plaster in an amount not to exceed that set forth in ASTM C926.

26.12.3 Limitations.

Gypsum plaster shall not be used on exterior surfaces.

26.12.4 Cement plaster.

Plaster coats shall be protected from freezing for a period of not less than 24 hours after set has occurred. Plaster shall be applied when the ambient temperature is higher than 40°F (4°C), unless provisions are made to keep cement plaster work above 4°C (40°F) during application and 48 hours thereafter.

26.12.5 Second-coat application.

The second coat shall be brought out to proper thickness, rodded and floated sufficiently rough to provide adequate bond for the finish coat. The second coat shall not have variations greater than 6.4 mm (\(\frac{1}{4}\) inch) in any direction under a 1524 mm (5-foot) straight edge.

26.12.6 Curing and interval.

First and second coats of cement plaster shall be applied and moist cured as set forth in ASTM C926 and Table 26.12.6.

<table>
<thead>
<tr>
<th>TABLE 26.12.6 CEMENT PLASTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COAT</strong></td>
</tr>
<tr>
<td>First</td>
</tr>
<tr>
<td>Second</td>
</tr>
<tr>
<td>Finish</td>
</tr>
</tbody>
</table>

\(^a\) The first two coats shall be as required for the first coats of exterior plaster, except that the moist-curing time period between the first and second coats shall be not less than 24 hours. Moist curing shall not be required where job and weather conditions are favorable to the retention of moisture in the cement plaster for the required time period.

\(^b\) Twenty-four-hour minimum interval between coats of interior cement plaster. For alternative method of application, see Clause 26.12.8.

\(^c\) Finish coat plaster is permitted to be applied to interior cement plaster base coats after a 48-hour period.

26.12.7 Application to solid backings.

Where applied over gypsum backing as specified in Clause 26.10.5 or directly to unit masonry surfaces, the second coat is permitted to be applied as soon as the first coat has attained sufficient hardiness.

26.12.8 Alternate method of application.

The second coat is permitted to be applied as soon as the first coat has attained sufficient rigidity to receive the second coat.

26.12.8.1 Admixtures.

Where using this method of application, calcium aluminate cement up to 15 percent of the weight of the Portland cement is permitted to be added to the mix.

26.12.8.2 Curing.

Curing of the first coat is permitted to be omitted and the second coat shall be cured as set forth in ASTM C926 and Table 26.12.6.


Cement plaster finish coats shall be applied over base coats that have been in place for the time periods set forth in ASTM C926. The third or finish coat shall be applied with sufficient material and pressure to bond and to cover the brown coat and shall be of sufficient thickness to conceal the brown coat.

26.13 EXPOSED AGGREGATE PLASTER


Exposed natural or integrally colored aggregate is permitted to be partially embedded in a natural or colored bedding coat of cement plaster or gypsum plaster, subject to the provisions of this clause.

26.13.2 Aggregate.

The aggregate shall be applied manually or mechanically and shall consist of marble chips, pebbles or similar durable, moderately hard (three or more on the Mohs hardness scale), nonreactive materials.
26.13.3 Bedding coat proportions.
The bedding coat for interior or exterior surfaces shall be composed of one part Portland cement and one part Type S lime; or one part blended cement and one part Type S lime; or masonry cement; or plastic cement and not more than three parts of graded white or natural sand by volume. The bedding coat for interior surfaces shall be composed of 100 pounds (45.4 kg) of neat gypsum plaster and not more than 200 pounds (90.8 kg) of graded white sand. A factory-prepared bedding coat for interior or exterior use is permitted. The bedding coat for exterior surfaces shall have a minimum compressive strength of 1,000 pounds per square inch (psi) (6895 kPa).

26.13.4 Application.
The bedding coat is permitted to be applied directly over the first (scratch) coat of plaster, provided that the ultimate overall thickness is not less than 22 mm (7/8 inch), including lath. Over concrete or masonry surfaces, the overall thickness shall be not less than 12.7 mm (1/2 inch).

26.13.5 Bases.
Exposed aggregate plaster is permitted to be applied over concrete, masonry, cement plaster base coats or gypsum plaster base coats installed in accordance with Clause 26.11 or 26.12.

26.13.6 Preparation of masonry and concrete.
Masonry and concrete surfaces shall be prepared in accordance with the provisions of Clause 26.10.7.

26.13.7 Curing of base coats.
Cement plaster base coats shall be cured in accordance with ASTM C926. Cement plaster bedding coats shall retain sufficient moisture for hydration (hardening) for 24 hours minimum or, where necessary, shall be kept damp for 24 hours by light water spraying.

26.14 REINFORCED GYPSUM CONCRETE

Reinforced gypsum concrete shall comply with the requirements of ASTM C317 and ASTM C956.

The minimum thickness of reinforced gypsum concrete shall be 51 mm (2 inches) except the minimum required thickness shall be reduced to 38 mm (1 1/2 inches), provided that the following conditions are satisfied:

1. The overall thickness, including the form board, is not less than 51 mm (2 inches).
2. The clear span of the gypsum concrete between supports does not exceed 838 mm (33 inches).
3. Diaphragm action is not required.
4. The design live load does not exceed 1915 Pa (40 pounds per square foot (psf)).

PART 27: PLASTICS

User note:
About this part: The use of plastics in building construction and components is addressed in Part 27. This part provides standards addressing foam plastic insulation, foam plastics used as interior finish and trim, and other plastic veneers used on the inside or outside of a building. This part addresses the use of light-transmitting plastics in various configurations such as walls, roof panels, skylights, signs and glazing. Requirements for the use of fibre-reinforced polymers, fibreglass-reinforced polymers and reflective plastic core insulation are also contained in this part. Additionally, requirements specific to the use of wood-plastic composites and plastic timber are contained in this part.

27.1 GENERAL

27.1.1 Scope.
These provisions shall govern the materials, design, application, construction and installation of foam plastic, foam plastic insulation, plastic veneer, interior plastic finish and trim, light-
transmitting plastics, fibre reinforced polymers, fibreglass reinforced polymers and plastic composites, including plastic timber.

27.2 FINISH AND TRIM
27.2.1 Exterior finish and trim.

See Part 15 for requirements for exterior wall finish and trim.

27.2.2 Interior finish and trim.

See Clause 27.4 for requirements for interior finish and trim.

27.3 FOAM PLASTIC INSULATION
27.3.1 General.

The provisions of this clause shall govern the requirements and uses of foam plastic insulation in buildings and structures.

27.3.2 Labeling and identification.

Packages and containers of foam plastic insulation and foam plastic insulation components delivered to the job site shall bear the label of an approved agency showing the manufacturer’s name, product listing, product identification and information sufficient to determine that the end use will comply with the Code requirements.

27.3.3 Surface-burning characteristics.

Unless otherwise indicated in this clause, foam plastic insulation and foam plastic cores of manufactured assemblies shall have a flame spread index of not more than 75 and a smoke-developed index of not more than 450 where tested in the maximum thickness intended for use in accordance with ASTM E84. Loose fill-type foam plastic insulation shall be tested as board stock for the flame spread and smoke-developed indices.

Exceptions:

1. Smoke-developed index for interior trim as provided for in Clause 27.4.2.

2. In cold storage buildings, ice plants, food plants, food processing rooms and similar areas, foam plastic insulation where tested in a thickness of 102 mm (4 inches) shall be permitted in a thickness up to 254 mm (10 inches) where the building is equipped throughout with an automatic fire sprinkler system in accordance with Clause 10.3.3.1.1. The approved automatic sprinkler system shall be provided in both the room and that part of the building in which the room is located.

3. Foam plastic insulation that is a part of a Class A, B or C roof-covering assembly provided that the assembly with the foam plastic insulation satisfactorily passes the Ghana Fire Code. The smoke-developed index shall not be limited for roof applications.

4. Foam plastic insulation greater than 102 mm (4 inches) in thickness shall have a maximum flame spread index of 75 and a smoke-developed index of 450 where tested at a minimum thickness of 102 mm (4 inches), provided that the end use is approved in accordance with Clause 27.3.9 using the maximum thickness and density intended for use.

5. Flame spread and smoke-developed indices for foam plastic interior signs in covered and open mall buildings provided that the signs comply with this Code.

27.3.4 Thermal barrier.

Except as provided for in Clauses 27.3.4.1 and 27.3.9, foam plastic shall be separated from the interior of a building by an approved thermal barrier of 12.7 mm (\(\frac{1}{2}\)-inch) gypsum wallboard, heavy timber in accordance with this Code or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of the Ghana Fire Code. Combustible concealed spaces shall comply with Clause 8.18.

27.3.4.1 Thermal barrier not required.

The thermal barrier specified in Clause 27.3.4 is
not required under the conditions set forth in Clauses 27.3.4.1.1 through 27.3.4.1.14.

27.3.4.1.1 Masonry or concrete construction.
A thermal barrier is not required for foam plastic installed in a masonry or concrete wall, floor or roof system where the foam plastic insulation is covered on each face by not less than 25 mm (1-inch) thickness of masonry or concrete.

27.3.4.1.2 Cooler and freezer walls.
Foam plastic installed in a maximum thickness of 254 mm (10 inches) in cooler and freezer walls shall:

1. Have a flame spread index of 25 or less and a smoke-developed index of not more than 450, where tested in a minimum 102 mm (4-inch) thickness.
2. Have flash ignition and self-ignition temperatures of not less than 600°F and 800°F (316°C and 427°C), respectively.
3. Have a covering of not less than 0.8 mm (0.032-inch) aluminum or corrosion-resistant steel having a base metal thickness not less than 0.4 mm (0.0160 inch) at any point.
4. Be protected by an automatic sprinkler system in accordance with Clause 10.3.3.1.1. Where the cooler or freezer is within a building, both the cooler or freezer and that part of the building in which it is located shall be sprinklered.

27.3.4.1.3 Walk-in coolers.
In nonsprinklered buildings, foam plastic having a thickness that does not exceed 102 mm (4 inches) and a maximum flame spread index of 75 is permitted in walk-in coolers or freezer units where the aggregate floor area does not exceed 37 m² (400 square feet) and the foam plastic is covered by a metal facing not less than 0.81 mm (0.032-inch-thick) aluminum or corrosion-resistant steel having a minimum base metal thickness of 0.41 mm (0.016 inch). A thickness of up to 254 mm (10 inches) is permitted where protected by a thermal barrier.

27.3.4.1.11 Interior trim.
Foam plastic used as interior trim in accordance with Clause 27.4 shall be permitted without a thermal barrier.

27.3.4.1.12 Interior signs.
Foam plastic used for interior signs in covered mall buildings in accordance with this Code shall be permitted without a thermal barrier. Foam plastic signs that are not affixed to interior building surfaces shall comply with the Ghana Fire Code.

27.3.4.1.13 Type III construction.
Foam plastic spray applied to a sill plate, joist header and rim joist in Type III construction is subject to all of the following:

1. The maximum thickness of the foam plastic shall be 82.6 mm (3 1/4 inches).
2. The density of the foam plastic shall be in the range of 1.5 to 2.0 pcf (24 to 32 kg/m3).
3. The foam plastic shall have a flame spread index of 25 or less and an accompanying smoke-developed index of 450 or less when tested in accordance with ASTM E84

27.3.4.1.14 Floors.
The thermal barrier specified in Clause 27.3.4 is not required to be installed on the walking surface of a structural floor system that contains foam plastic insulation where the foam plastic is covered by a minimum nominal 1/2-inch-thick (12.7 mm) wood structural panel or approved equivalent. The thermal barrier specified in Clause 27.3.4 is required on the underside of the structural floor system that contains foam plastic insulation where the underside of the structural floor system is exposed to the interior of the building.
Exception: Foam plastic used as part of an interior floor finish.

27.3.5 Exterior walls of buildings of any height.
Exterior walls of buildings of Type I, II, or III construction of any height shall comply with Clauses 27.3.5.1 through 27.3.5.7. Exterior walls of cold storage buildings required to be constructed of noncombustible materials, where the building is more than one storey in height, shall comply with the provisions of Clauses 27.3.5.1 through 27.3.5.7. Exterior walls of buildings of Type IV construction shall comply with Clauses 27.3.2, 27.3.3 and 27.3.4. Fireblocking shall be in accordance with this Code.

27.3.5.1 Fire-resistance-rated walls.
Where the wall is required to have a fire-resistance rating, data based on tests conducted in accordance with ASTM E119 shall be provided to substantiate that the fire-resistance rating is maintained.

27.3.5.2 Thermal barrier.
Any foam plastic insulation shall be separated from the building interior by a thermal barrier meeting the provisions of Clause 27.3.4, unless special approval is obtained on the basis of Clause 27.3.9.

27.3.5.3 Potential heat.
The potential heat of foam plastic insulation in any portion of the wall or panel shall not exceed the potential heat expressed in Btu per square foot (mJ/m²) of the foam plastic insulation contained in the wall assembly tested in accordance with Clause 27.3.5.5. The potential heat of the foam plastic insulation shall be determined by tests conducted in accordance with the Ghana Fire Code and the results shall be expressed in Btu per square foot (mJ/m²).

27.3.5.4 Flame spread and smoke-developed indices.
Foam plastic insulation, exterior coatings and facings shall be tested separately in the thickness intended for use, but not to exceed 102 mm (4 inches), and shall each have a flame spread index of 25 or less and a smoke-developed index of 450 or less as determined in accordance with ASTM E84.

Exception: Prefabricated or factory-manufactured panels having minimum 0.020-inch (0.51 mm) aluminum facings and a total thickness of 6.4 mm (1/4 inch) or less are permitted to be tested as an assembly where the foam plastic core is not exposed in the course of construction.

27.3.5.5 Vertical and lateral fire propagation.
The exterior wall assembly shall be tested in accordance with and comply with the acceptance criteria of the Ghana Fire Code.

Exceptions:

1. Wall assemblies where the foam plastic insulation is covered on each face by not less than 25 mm (1-inch) thickness of masonry or concrete and meeting one of the following:

   1.1. There is no airspace between the insulation and the concrete or masonry.

   1.2. The insulation has a flame spread index of not more than 25 as determined in accordance with ASTM E84 and the maximum airspace between the insulation and the concrete or masonry is not more than 25 mm (1 inch).

27.3.5.6 Label required.
The edge or face of each piece, package or container of foam plastic insulation shall bear the label of an approved agency. The label shall contain the manufacturer’s or distributor’s identification, model number, serial number or definitive information describing the product or materials’ performance characteristics and approved agency’s identification.
27.3.5.7 Ignition.

Exterior walls shall not exhibit sustained flaming where tested in accordance with the Ghana Fire Code. Where a material is intended to be installed in more than one thickness, tests of the minimum and maximum thickness intended for use shall be performed.

**Exception:** Assemblies protected on the outside with one of the following:

1. A thermal barrier complying with Clause 27.3.4.
2. A minimum 25 mm (1-inch) thickness of concrete or masonry.
4. Metal-faced panels having minimum 0.48 mm (0.019-inch) aluminum or 0.41 mm (0.016-inch) corrosion-resistant steel outer facings.
5. A minimum thickness of stucco complying with Clause 26.10.
6. A minimum 6.4 mm (1/4-inch) thickness of fibre-cement lap, panel or shingle siding complying with this Code.

27.3.6 Roofing.

Foam plastic insulation meeting the requirements of Clauses 27.3.2, 27.3.3 and 27.3.4 shall be permitted as part of a roof-covering assembly, provided that the assembly with the foam plastic insulation is a Class A, B or C roofing assembly where tested in accordance with ASTM E108.

27.3.7 Foam plastic in plenums as interior finish or interior trim.

Foam plastic in plenums used as interior wall or ceiling finish, or interior trim, shall exhibit a flame spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E84 at the maximum thickness and density intended for use, and shall be tested in accordance with ASTM E84 and meet the acceptance criteria of this Code. As an alternative to testing to ASTM E84, the foam plastic shall be approved based on tests conducted in accordance with Clause 27.3.9.

**Exceptions:**

1. Foam plastic in plenums used as interior wall or ceiling finish, or interior trim, shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E84 at the maximum thickness and density intended for use, where it is separated from the airflow in the plenum by a thermal barrier complying with Clause 27.3.4.
2. Foam plastic in plenums used as interior wall or ceiling finish, or interior trim, shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E84 or at the maximum thickness and density intended for use, where it is separated from the airflow in the plenum by corrosion-resistant steel having a base metal thickness of not less than 0.4 mm (0.0160 inch).
3. Foam plastic in plenums used as interior wall or ceiling finish, or interior trim, shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E84 or at the maximum thickness and density intended for use, where it is separated from the airflow in the plenum by not less
than a 25 mm (1-inch) thickness of masonry or concrete.

27.3.8 Protection against termites.
In areas where the probability of termite infestation is very heavy, extruded and expanded polystyrene, polyisocyanurate and other foam plastics shall not be installed on the exterior face or under interior or exterior foundation walls or slab foundations located below grade. The clearance between foam plastics installed above grade and exposed earth shall be not less than 152 mm (6 inches).

Exceptions:
1. Buildings where the structural members of walls, floors, ceilings and roofs are entirely of noncombustible materials or preservative-treated wood.
2. An approved method of protecting the foam plastic and structure from subterranean termite damage is provided.
3. On the interior side of basement walls.

27.3.9 Special approval.
Foam plastic shall not be required to comply with the requirements of Clause 27.3.4 or those of Clause 27.3.6 where specifically approved based on large-scale tests such as, but not limited to, ASTM E84 with the acceptance criteria of this Code. Such testing shall be related to the actual end-use configuration and be performed on the finished manufactured foam plastic assembly in the maximum thickness intended for use. Foam plastics that are used as interior finish on the basis of special tests shall conform to the flame spread and smoke-developed requirements of Part 8 (Fire and Smoke Protection system). Assemblies tested shall include seams, joints and other typical details used in the installation of the assembly and shall be tested in the manner intended for use.

27.3.10 Wind resistance.
Foam plastic insulation complying with ASTM C578 and ASTM C1289 and used as exterior wall sheathing on framed wall assemblies shall comply with Part 17 (Structural loads and design) for wind pressure resistance.

27.3.11 Cladding attachment over foam sheathing to masonry or concrete wall construction.
Cladding shall be specified and installed in accordance with Part 14 and the cladding manufacturer’s installation instructions or an approved design. Foam sheathing shall be attached to masonry or concrete construction in accordance with the insulation manufacturer’s installation instructions or an approved design. Furring and furring attachments through foam sheathing shall be designed to resist design loads determined in accordance with Part 17 (Structural loads and Design), including support of cladding weight as applicable. Fasteners used to attach cladding or furring through foam sheathing to masonry or concrete substrates shall be approved for application into masonry or concrete material and shall be installed in accordance with the fastener manufacturer’s installation instructions.

Exceptions:
1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing and connection to a masonry or concrete substrate, those requirements shall apply.
2. For exterior insulation and finish systems, refer to Clause 15.7.
3. For anchored masonry or stone veneer installed over foam sheathing, refer to Clause 15.4.

27.3.12 Cladding attachment over foam sheathing to cold-formed steel framing.
Cladding shall be specified and installed in accordance with Part 15 and the cladding manufacturer’s approved installation instructions, including any limitations for use over foam plastic sheathing, or an approved design. Where used, furring and furring
attachments shall be designed to resist design loads determined in accordance with Part 17. In addition, the cladding or furring attachments through foam sheathing to cold-formed steel framing shall meet or exceed the minimum fastening requirements of Clauses 27.3.12.1 and 27.3.12.2, or an approved design for support of cladding weight.

Exceptions:

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing, those requirements shall apply.

2. For exterior insulation and finish systems, refer to Clause 15.7.

27.3.12.1 Direct attachment.

Where cladding is installed directly over foam sheathing without the use of furring, cladding minimum fastening requirements to support the cladding weight shall be as specified in Table 27.3.12.1.

### TABLE 27.3.12.1

CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT

<table>
<thead>
<tr>
<th>CLADDING FASTENER THROUGH FOAM SHEATHING INTO:</th>
<th>CLADDING FASTENER TYPE AND MINIMUM SIZE&lt;sup&gt;b&lt;/sup&gt;</th>
<th>CLADDING FASTENER VERTICAL SPACING (inches)</th>
<th>MAXIMUM THICKNESS OF FOAM SHEATHING&lt;sup&gt;c&lt;/sup&gt; (inches)</th>
<th>16&quot; o.c. fastener horizontal spacing</th>
<th>24&quot; o.c. fastener horizontal spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-formed steel framing (minimum penetration of steel thickness plus 3 threads)</td>
<td>#8 screw into 33 mil steel or thicker</td>
<td>6</td>
<td>3.00</td>
<td>2.95</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>3.00</td>
<td>2.55</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>3.00</td>
<td>1.80</td>
<td>DR</td>
</tr>
<tr>
<td></td>
<td>#10 screw into 33 mil steel</td>
<td>6</td>
<td>4.00</td>
<td>3.50</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>4.00</td>
<td>3.10</td>
<td>2.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>4.00</td>
<td>2.25</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>#10 screw into 43 mil steel or thicker</td>
<td>6</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>4.00</td>
<td>4.00</td>
<td>3.70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>4.00</td>
<td>3.85</td>
<td>2.80</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot (psf) = 0.0479 kPa, 1 pound per square inch = 0.00689 MPa.

DR = design required, o.c. = on center.

a. Cold-formed steel framing shall be minimum 33 ksi steel for 33 mil and 43 mil steel and 50 ksi steel for 54 mil steel or thicker.
b. Screws shall comply with the requirements of AISI S240.
c. Foam sheathing shall have a minimum compressive strength of 15 pounds per square inch in accordance with ASTM C578 or ASTM C1289.

27.3.12.2 Furred cladding attachment.
Where steel or wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table 27.3.12.2. Where placed horizontally, wood furring shall be preservative-treated wood in accordance with Clause 24.3.1.9 or naturally durable wood and fasteners shall be corrosion resistant in accordance Clause 24.4.10.5. Steel furring shall have a minimum G60 galvanized coating.

### TABLE 27.3.12.2
**FURRING MINIMUM FASTENING REQUIREMENTS FOR APPLICATION OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT**

<table>
<thead>
<tr>
<th>FURRING MATERIAL</th>
<th>FRAMING MEMBER</th>
<th>FASTENER TYPE AND MINIMUM SIZE</th>
<th>MINIMUM PENETRATION INTO WALL FRAMING (inches)</th>
<th>FASTENER SPACING IN FURRING (inches)</th>
<th>MAXIMUM THICKNESS OF FOAM SHEATHING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 mil cold-formed steel stud</td>
<td>16&quot; o.c. furring</td>
<td>#8 screw</td>
<td>Steel thickness plus 3 threads</td>
<td>12</td>
<td>3.00 1.80 DR DR</td>
</tr>
<tr>
<td></td>
<td>24&quot; o.c. furring</td>
<td>#8 screw</td>
<td>Steel thickness plus 3 threads</td>
<td>12</td>
<td>2.85 DR DR</td>
</tr>
<tr>
<td>43 mil or thicker cold-formed steel stud</td>
<td></td>
<td>#8 Screw</td>
<td>Steel thickness plus 3 threads</td>
<td>12</td>
<td>3.00 2.25 0.70 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#10 Screw</td>
<td>Steel thickness plus 3 threads</td>
<td>16</td>
<td>3.85 1.45 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24</td>
<td>3.40 DR DR</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>3.00 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.85 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.25 DR DR</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>3.00 0.65 DR DR</td>
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<td></td>
<td></td>
<td></td>
<td>1.05 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.65 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.25 0.65 DR DR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.50 0.65 DR DR</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot (psf) = 0.0479 kPa, 1 pound per square inch = 0.00689 MPa.

a. Wood furring shall be spruce-pine-fir or any softwood species with a specific gravity of 0.42 or greater. Steel furring shall be minimum 33 ksi steel. Cold-formed steel studs shall be minimum 33 ksi steel for 33 mil and 43 mil thickness and 50 ksi steel for 54 mil steel or thicker.
b. Screws shall comply with the requirements of AISI S240.
c. Where the required cladding fastener penetration into wood material exceeds $\frac{3}{4}$ inch and is not more than $1 \frac{1}{2}$ inches, a minimum 2-inch nominal wood furring or an approved design shall be used.
d. Foam sheathing shall have a minimum compressive strength of 15 pounds per square inch in accordance with ASTM C578 or ASTM C1289.

e. Furring shall be spaced not more than 24 inches on center, in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

27.3.13 Cladding attachment over foam sheathing to wood framing.

Cladding shall be specified and installed in accordance with Part 15 (Exterior Walls) and the cladding manufacturer’s installation instructions. Where used, furring and furring attachments shall be designed to resist design loads determined in accordance with Part 17 (Structural Loads and design). In addition, the cladding or furring attachments through foam sheathing to framing shall meet or exceed the minimum fastening requirements of Clause 27.3.13.1 or 27.3.13.2, or an approved design for support of cladding weight.

Exceptions:

1. Where the cladding manufacturer has provided approved installation instructions for application over foam sheathing, those requirements shall apply.

2. For exterior insulation and finish systems, refer to Clause 15.7.

3. For anchored masonry or stone veneer installed over foam sheathing, refer to Clause 15.4.

27.3.13.1 Direct attachment.

Where cladding is installed directly over foam sheathing without the use of furring, minimum fastening requirements to support the cladding weight shall be as specified in Table 27.3.13.1.

---

TABLE 27.3.13.1
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT

<table>
<thead>
<tr>
<th>CLADDING FASTENER THROUGH FOAM SHEATHING INTO:</th>
<th>CLADDING FASTENER TYPE AND MINIMUM SIZE</th>
<th>MAXIMUM THICKNESS OF FOAM SHEATHING (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Framing (minimum 1 1/4-inch penetration)</td>
<td>0.113&quot; diameter nail</td>
<td>16&quot; o.c. fastener horizontal spacing</td>
</tr>
<tr>
<td></td>
<td>0.120&quot; diameter nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.131&quot; diameter nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.162&quot; diameter nail</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24&quot; o.c. fastener horizontal spacing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>3 psf</th>
<th>11 psf</th>
<th>18 psf</th>
<th>25 psf</th>
<th>3 psf</th>
<th>11 psf</th>
<th>18 psf</th>
<th>25 psf</th>
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<tbody>
<tr>
<td>6</td>
<td>2.00</td>
<td>1.45</td>
<td>0.75</td>
<td>DR</td>
<td>2.00</td>
<td>0.85</td>
<td>DR</td>
<td>DR</td>
</tr>
<tr>
<td>8</td>
<td>2.00</td>
<td>1.00</td>
<td>DR</td>
<td>DR</td>
<td>2.00</td>
<td>0.55</td>
<td>DR</td>
<td>DR</td>
</tr>
<tr>
<td>12</td>
<td>2.00</td>
<td>0.55</td>
<td>DR</td>
<td>DR</td>
<td>1.85</td>
<td>1.05</td>
<td>0.50</td>
<td>DR</td>
</tr>
<tr>
<td>6</td>
<td>3.00</td>
<td>1.70</td>
<td>0.90</td>
<td>0.55</td>
<td>3.00</td>
<td>1.05</td>
<td>0.50</td>
<td>DR</td>
</tr>
<tr>
<td>8</td>
<td>3.00</td>
<td>1.20</td>
<td>0.60</td>
<td>DR</td>
<td>3.00</td>
<td>0.70</td>
<td>DR</td>
<td>DR</td>
</tr>
<tr>
<td>12</td>
<td>3.00</td>
<td>0.70</td>
<td>DR</td>
<td>DR</td>
<td>2.15</td>
<td>0.70</td>
<td>DR</td>
<td>DR</td>
</tr>
<tr>
<td>6</td>
<td>4.00</td>
<td>2.15</td>
<td>1.20</td>
<td>0.75</td>
<td>4.00</td>
<td>1.35</td>
<td>0.70</td>
<td>DR</td>
</tr>
<tr>
<td>8</td>
<td>4.00</td>
<td>1.55</td>
<td>0.80</td>
<td>DR</td>
<td>4.00</td>
<td>0.90</td>
<td>DR</td>
<td>DR</td>
</tr>
<tr>
<td>12</td>
<td>4.00</td>
<td>0.90</td>
<td>DR</td>
<td>DR</td>
<td>2.70</td>
<td>0.50</td>
<td>DR</td>
<td>DR</td>
</tr>
<tr>
<td>6</td>
<td>4.00</td>
<td>3.55</td>
<td>2.05</td>
<td>1.40</td>
<td>4.00</td>
<td>2.25</td>
<td>1.25</td>
<td>0.80</td>
</tr>
<tr>
<td>8</td>
<td>4.00</td>
<td>2.55</td>
<td>1.45</td>
<td>0.95</td>
<td>4.00</td>
<td>1.60</td>
<td>0.85</td>
<td>0.50</td>
</tr>
<tr>
<td>12</td>
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<td>0.85</td>
<td>0.50</td>
<td>4.00</td>
<td>0.95</td>
<td>DR</td>
<td>DR</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot (psf) = 0.0479 kPa.

DR = Design Required, o.c. = on center.
a. Wood framing shall be spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with ANSI/AWC NDS.
b. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.

### 27.3.13.2 Furred cladding attachment.

Where wood furring is used to attach cladding over foam sheathing, furring minimum fastening requirements to support the cladding weight shall be as specified in Table 27.3.13.2. Where placed horizontally, wood furring shall be preservative-treated wood in accordance with Clause 24.3.1.9 or naturally durable wood and fasteners shall be corrosion resistant in accordance with Clause 24.4.10.5.

#### TABLE 27.3.13.2

<table>
<thead>
<tr>
<th>FURRING MATERIAL</th>
<th>FRAMING MEMBER</th>
<th>FASTENER TYPE AND MINIMUM SIZE</th>
<th>MINIMUM PENETRATION INTO WALL FRAMING (INCHES)</th>
<th>FASTENER SPACING IN FURRING (INCHES)</th>
<th>MAXIMUM THICKNESS OF FOAM SHEATHING (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum 2x Wood Stud</td>
<td>0.131&quot; diameter nail</td>
<td>1/4</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.162&quot; diameter nail</td>
<td>1/4</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. 10 wood screw</td>
<td>1</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/4&quot; lag screw</td>
<td>1 1/2</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 pound per square foot (psf) = 0.0479 kPa, 1 pound per square inch = 0.00689 MPa.

DR = Design Required, o.c. = on center.

a. Wood framing and furring shall be spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with ANSI/AWC NDS.
b. Nail fasteners shall comply with ASTM F1667, except nail length shall be permitted to exceed ASTM F1667 standard lengths.
c. Where the required cladding fastener penetration into wood material exceeds $\frac{3}{4}$ inch and is not more than $1\frac{1}{2}$ inches, a minimum 2-inch nominal wood furring or an approved design shall be used.
d. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C578 or ASTM C1289.
e. Furring shall be spaced not greater than 24 inches on center in a vertical or horizontal orientation. In a vertical orientation, furring shall be located over wall studs and attached with the required fastener spacing. In a horizontal orientation, the
indicated 8-inch and 12-inch fastener spacing in furring shall be achieved by use of two fasteners into studs at 16 inches and 24 inches on center, respectively.

27.4 INTERIOR FINISH AND TRIM

27.4.1 General.
Plastic materials installed as interior finish or trim shall comply with Part 9. Foam plastics shall only be installed as interior finish where approved in accordance with the special provisions of Clause 27.3.9. Foam plastics that are used as interior finish shall meet the flame spread and smoke-developed index requirements for interior finish in accordance with Part 9. Foam plastics installed as interior trim shall comply with Clause 27.4.2.

27.4.1.1 Plenums.
Foam plastics installed in plenums as interior wall or ceiling finish shall comply with Clause 27.3.7. Foam plastics installed in plenums as interior trim shall comply with Clauses 27.4.2 and 27.3.7.

27.4.2 Interior trim.
Foam plastic used as interior trim shall comply with Clauses 27.4.2.1 through 27.4.2.4.

27.4.2.1 Density.
The minimum density of the interior trim shall be 320 kg/m$^3$ (20 pcf).

27.4.2.2 Thickness.
The maximum thickness of the interior trim shall be 12.7 mm ($\frac{1}{2}$ inch) and the maximum width shall be 204 mm (8 inches).

27.4.2.3 Area limitation.
The interior trim shall not constitute more than 10 percent of the specific wall or ceiling areas to which it is attached.

27.4.2.4 Flame spread.
The flame spread index shall not exceed 75 where tested in accordance with ASTM E84. The smoke-developed index shall not be limited.

Exception: Where the interior trim material has been tested as an interior finish in accordance with ASTM E84 and complies with the acceptance criteria in Clause 9.3.1.1.1, it shall not be required to be tested for flame spread index in accordance with ASTM E84.

27.5 PLASTIC FINISH

27.5.1 Interior use.
Where used within a building, plastic veneer shall comply with the interior finish requirements of Part 9.

27.5.2 Exterior use.
Exterior plastic finish, other than plastic siding, shall be permitted to be installed on the exterior walls of buildings of any type of construction in accordance with all of the following requirements:

1. Plastic veneer shall comply with Clause 27.6.4.
2. Plastic veneer shall not be attached to any exterior wall to a height greater than 15 240 mm (50 feet) above grade.
3. Clauses of plastic veneer shall not exceed 27.9 m$^2$ (300 square feet) in area and shall be separated by not less than 1219 mm (4 feet) vertically.

27.5.3 Plastic siding.
Plastic siding shall comply with the requirements of Clauses 15.3 and 15.4.

27.6 LIGHT-TRANSMITTING PLASTICS

27.6.1 General.
The provisions of this clause and Clauses 27.7 through 27.11 shall govern the quality and methods of application of light-transmitting plastics for use as light-transmitting materials in buildings and structures. Foam plastics shall comply with Clause 27.3. Light-transmitting plastic materials that meet the other Code requirements for walls and roofs shall be permitted to be used in accordance with the other applicable parts of the Code.

27.6.2 Approval for use.
Sufficient technical data shall be submitted to substantiate the proposed use of any light-
transmitting material, as approved by the Head of Works department and subject to the requirements of this clause.

27.6.3 Identification.
Each unit or package of light-transmitting plastic shall be identified with a mark or decal satisfactory to the Head of Works department, which includes identification as to the material classification.

27.6.4 Specifications.
Light-transmitting plastics, including thermoplastic, thermosetting or reinforced thermosetting plastic material, shall have a self-ignition temperature of 343°C (650°F) or greater where tested in accordance with ASTM D1929; a smoke-developed index not greater than 450 where tested in the manner intended for use in accordance with ASTM E84, or a maximum average smoke density rating not greater than 75 where tested in the thickness intended for use in accordance with ASTM D2843 and shall conform to one of the following combustibility classifications:

Class CC1:
Plastic materials that have a burning extent of 25 mm (1 inch) or less where tested at a nominal thickness of 1.5 mm (0.060 inch), or in the thickness intended for use, in accordance with ASTM D635.

Class CC2:
Plastic materials that have a burning rate of 1.06 mm/s (2 1/2 inches per minute) or less where tested at a nominal thickness of 1.5 mm (0.060 inch), or in the thickness intended for use, in accordance with ASTM D635.

27.6.5 Structural requirements.
Light-transmitting plastic materials in their assembly shall be of adequate strength and durability to withstand the loads indicated in Part 17. Technical data shall be submitted to establish stresses, maximum unsupported spans and such other information for the various thicknesses and forms used as deemed necessary by the Head of Works department.

27.6.6 Fastening.
Fastening shall be adequate to withstand the loads in Part 17. Proper allowance shall be made for expansion and contraction of light-transmitting plastic materials in accordance with accepted data on the coefficient of expansion of the material and other material in conjunction with which it is employed.

27.6.7 Light-diffusing systems.
Unless the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, light-diffusing systems shall not be installed in the following occupancies and locations:

1. Group A with an occupant load of 1,000 or more.
2. Theaters with a stage and proscenium opening and an occupant load of 700 or more.
5. Interior exit stairways and ramps and exit passageways.

27.6.7.1 Support.
Light-transmitting plastic diffusers shall be supported directly or indirectly from ceiling or roof construction by use of noncombustible hangers. Hangers shall be not less than No. 12 steel-wire gage (0.106 inch) galvanized wire or equivalent.

27.6.7.2 Installation.
Light-transmitting plastic diffusers shall comply with Part 9 unless the light-transmitting plastic diffusers will fall from the mountings before igniting, at an ambient temperature of not less than 111°C (200°F) below the ignition temperature of the panels. The panels shall remain in place at an ambient room temperature of 79°C (175°F) for a period of not less than 15 minutes.
27.6.7.3 Size limitations.

Individual panels or units shall not exceed 3048 mm (10 feet) in length nor 2.79 m² (30 square feet) in area.

27.6.7.4 Fire suppression system.

In buildings that are equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, plastic light-diffusing systems shall be protected both above and below unless the sprinkler system has been specifically approved for installation only above the light-diffusing system. Areas of light-diffusing systems that are protected in accordance with this clause shall not be limited.

27.6.7.5 Electrical luminaires.

Light-transmitting plastic panels and light-diffuser panels that are installed in approved electrical luminaires shall comply with the requirements of Part 9 unless the light-transmitting plastic panels conform to the requirements of Clause 27.6.7.2. The area of approved light-transmitting plastic materials that is used in required exits or corridors shall not exceed 30 percent of the aggregate area of the ceiling in which such panels are installed, unless the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

27.6.8 Partitions.

Light-transmitting plastics used in or as partitions shall comply with the requirements of Parts 7 and 9.

27.6.9 Bathroom accessories.

Light-transmitting plastics shall be permitted as glazing in shower stalls, shower doors, bathtub enclosures and similar accessory units. Safety glazing shall be provided in accordance with Part 25.

27.6.10 Awnings, patio covers and similar structures.

Awnings constructed of light-transmitting plastics shall be constructed in accordance with the provisions specified in Clause 32.5 and Part 33 for projections. Patio covers constructed of light-transmitting plastics shall comply with Clause 27.6. Light-transmitting plastics used in canopies at motor fuel-dispensing facilities shall comply with Clause 27.6, except as modified by this Code.

27.6.11 Greenhouses.

Light-transmitting plastics shall be permitted in lieu of glass in greenhouses.

27.6.12 Solar collectors.

Light-transmitting plastic covers on solar collectors having noncombustible sides and bottoms shall be permitted on buildings not over three stories above grade plane or 836.1 m² (9,000 square feet) in total floor area, provided that the light-transmitting plastic cover does not exceed 33.33 percent of the roof area for CC1 materials or 25 percent of the roof area for CC2 materials.

Exception: Light-transmitting plastic covers having a thickness of 0.3 mm (0.010 inch) or less shall be permitted to be of any plastic material provided that the area of the solar collectors does not exceed 33.33 percent of the roof area.

27.7 LIGHT-TRANSMITTING PLASTIC WALL PANELS

27.7.1 General.

Light-transmitting plastics shall not be used as wall panels in exterior walls in occupancies in Groups A-1, A-2, H, I-2 and I-3. In other groups, light-transmitting plastics shall be permitted to be used as wall panels in exterior walls, provided that the walls are not required to have a fire-resistance rating and the installation conforms to the requirements of this clause. Such panels shall be erected and anchored on a foundation, waterproofed or otherwise protected from moisture absorption and sealed with a coat of mastic or other approved waterproof coating. Light-transmitting plastic wall panels shall comply with Clause 27.6.

27.7.2 Installation.

Exterior wall panels installed as provided for herein shall not alter the type of construction classification of the building.
27.7.3 Height limitation.

Light-transmitting plastics shall not be installed more than 22,860 mm (75 feet) above grade plane, except as allowed by Clause 28.7.5.

27.7.4 Area limitation and separation.

The maximum area of a single wall panel and minimum vertical and horizontal separation requirements for exterior light-transmitting plastic wall panels shall be as provided for in Table 27.7.4. The maximum percentage of wall area of any storey in light-transmitting plastic wall panels shall not exceed that indicated in Table 27.7.4 or the percentage of unprotected openings permitted by Clause 8.5.8, whichever is smaller.

Exceptions:

1. In structures provided with approved flame barriers extending 760 mm (30 inches) beyond the exterior wall in the plane of the floor, a vertical separation is not required at the floor except that provided by the vertical thickness of the flame barrier projection.

2. Veneers of approved weather-resistant light-transmitting plastics used as exterior siding in buildings of Type IV construction in compliance with Clause 15.5.

3. The area of light-transmitting plastic wall panels in exterior walls of greenhouses shall be exempt from the area limitations of Table 27.7.4 but shall be limited as required for unprotected openings in accordance with Clause 8.5.8.

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE (feet)</th>
<th>CLASS OF PLASTIC</th>
<th>MAXIMUM PERCENTAGE AREA OF EXTERIOR WALL IN PLASTIC WALL PANELS</th>
<th>MAXIMUM SINGLE AREA OF PLASTIC WALL PANELS (square feet)</th>
<th>MINIMUM SEPARATION OF PLASTIC WALL PANELS (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6</td>
<td>—</td>
<td>Not Permitted</td>
<td>Not Permitted</td>
<td>—</td>
</tr>
<tr>
<td>6 or more but less than 11</td>
<td>CC1</td>
<td>10</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>CC2</td>
<td>Not Permitted</td>
<td>Not Permitted</td>
<td>—</td>
</tr>
<tr>
<td>11 or more but less than or equal to 30</td>
<td>CC1</td>
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<td></td>
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<td>3\textsuperscript{b}</td>
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<td></td>
<td>CC2</td>
<td>50</td>
<td>100</td>
<td>6\textsuperscript{b}</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m\textsuperscript{2}

a. For combinations of plastic glazing and plastic wall panel areas permitted, see Clause 27.7.6.

b. For reductions in vertical separation allowed, see Clause 27.7.4.

27.7.5 Automatic sprinkler system.

Where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the maximum percentage area of exterior wall in any storey in light-transmitting plastic wall panels and the maximum square footage of a single area given in Table 27.7.4 shall be increased 100 percent, but the area of light-transmitting plastic wall panels shall not exceed 50 percent of the wall area in any storey, or the area permitted by Clause 8.5.8 for unprotected openings.
whichever is smaller. These installations shall be exempt from height limitations.

27.7.6 Combinations of glazing and wall panels.

Combinations of light-transmitting plastic glazing and light-transmitting plastic wall panels shall be subject to the area, height and percentage limitations and the separation requirements applicable to the class of light-transmitting plastic as prescribed for light-transmitting plastic wall panel installations.

27.8 LIGHT-TRANSMITTING PLASTIC GLAZING

27.8.1 Buildings of Type VB construction.

Openings in the exterior walls of buildings of Type VB construction, where not required to be protected by this Code, shall be permitted to be glazed or equipped with light-transmitting plastic. Light-transmitting plastic glazing shall comply with Clause 27.6.

27.8.2 Buildings of other types of construction.

Openings in the exterior walls of buildings of types of construction other than Type VB, where not required to be protected by Clause 8.5, shall be permitted to be glazed or equipped with light-transmitting plastic in accordance with Clause 27.6 and all of the following:

1. The aggregate area of light-transmitting plastic glazing shall not exceed 25 percent of the area of any wall face of the storey in which it is installed. The area of a single pane of glazing installed above the first storey above grade plane shall not exceed 1.5 m$^2$ (16 square feet) and the vertical dimension of a single pane shall not exceed 1219 mm (4 feet).

Exception: Where an automatic sprinkler system is provided throughout in accordance with Clause 10.3.3.1.1, the area of allowable glazing shall be increased to not more than 50 percent of the wall face of the storey in which it is installed with no limit on the maximum dimension or area of a single pane of glazing.

2. Approved flame barriers extending 762 mm (30 inches) beyond the exterior wall in the plane of the floor, or vertical panels not less than 4 feet (1219 mm) in height, shall be installed between glazed units located in adjacent stories.

Exception: Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

3. Light-transmitting plastics shall not be installed more than 22 860 mm (75 feet) above grade level.

Exception: Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

27.9 LIGHT-TRANSMITTING PLASTIC ROOF PANELS

27.9.1 General.

Light-transmitting plastic roof panels shall comply with this clause and Clause 27.6. Light-transmitting plastic roof panels shall not be installed in Groups H, I-2 and I-3. In all other groups, light-transmitting plastic roof panels shall comply with any one of the following conditions:

1. The building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

2. The roof construction is not required to have a fire-resistance rating by Table 7.1.

3. The roof panels meet the requirements for roof coverings in accordance with Part 16.

27.9.2 Separation.

Individual roof panels shall be separated from each other by a distance of not less than 1219 mm (4 feet) measured in a horizontal plane.

Exceptions:

1. The separation between roof panels is not required in a building equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.
2. The separation between roof panels is not required in low-hazard occupancy buildings complying with the conditions of Clause 27.9.4, Exception 2 or 3.

27.9.3 Location.
Where exterior wall openings are required to be protected by Clause 8.5.8, a roof panel shall not be installed within 1829 mm (6 feet) of such exterior wall.

27.9.4 Area limitations.
Roof panels shall be limited in area and the aggregate area of panels shall be limited by a percentage of the floor area of the room or space sheltered in accordance with Table 27.9.4.

Exceptions:
1. The area limitations of Table 27.9.4 shall be permitted to be increased by 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

2. Low-hazard occupancy buildings, such as swimming pool shelters, shall be exempt from the area limitations of Table 27.9.4, provided that the buildings do not exceed 465 m² (5,000 square feet) in area and have a minimum fire separation distance of 3048 mm (10 feet).

3. Greenhouses that are occupied for growing or maintaining plants, without public access, shall be exempt from the area limitations of Table 27.9.4 provided that they have a minimum fire separation distance of 1220 mm (4 feet).

4. Roof coverings over terraces and patios in occupancies in Group R-3 shall be exempt from the area limitations of Table 27.9.4 and shall be permitted with light-transmitting plastics.

### Table 27.9.4

<table>
<thead>
<tr>
<th>CLASS OF PLASTIC</th>
<th>MAXIMUM AREA OF INDIVIDUAL ROOF PANELS (square feet)</th>
<th>MAXIMUM AGGREGATE AREA OF ROOF PANELS (percent of floor area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC1</td>
<td>300</td>
<td>30</td>
</tr>
<tr>
<td>CC2</td>
<td>100</td>
<td>25</td>
</tr>
</tbody>
</table>

For SI: 1 square foot = 0.0929 m².

27.10 LIGHT-TRANSMITTING PLASTIC SKYLIGHT GLAZING

27.10.1 Light-transmitting plastic glazing of skylight assemblies.
Skylight assemblies glazed with light-transmitting plastic shall conform to the provisions of this clause and Clause 27.6. Unit skylights glazed with light-transmitting plastic shall comply with Clause 25.5.5.

Exception: Skylights in which the light-transmitting plastic conforms to the required roof-covering class in accordance with Clause 16.5.

27.10.2 Mounting.
The light-transmitting plastic shall be mounted above the plane of the roof on a curb constructed in accordance with the requirements for the type of construction classification, but not less than 102 mm (4 inches) above the plane of the roof. Edges of the light-transmitting plastic skylights or domes shall be protected by metal or other approved noncombustible material, or the light transmitting plastic dome or skylight shall be shown to be able to resist ignition where exposed at the edge to a flame from a Class B brand as described in ASTM E108. The Class B brand test shall be conducted on a skylight that is elevated to a height as specified in the manufacturer’s installation instructions, but not less than 102 mm (4 inches).
Exceptions:

1. Curbs shall not be required for skylights used on roofs having a minimum slope of three units vertical in 12 units horizontal (25-percent slope) in occupancies in Group R-3 and on buildings with a nonclassified roof covering.

2. The metal or noncombustible edge material is not required where nonclassified roof coverings are permitted.

27.10.3 Slope.

Flat or corrugated light-transmitting plastic skylights shall slope not less than one units vertical in 3 units horizontal (1:3). Dome-shaped skylights shall rise above the mounting flange a minimum distance equal to 10 percent of the maximum width of the dome but not less than 75 mm (3 inches).

Exception: Skylights that pass the Class B Burning Brand Test specified in ASTM E108.

27.10.4 Maximum area of skylights.

Each skylight shall have a maximum area within the curb of 9.3 m² (100 square feet).

Exception: The area limitation shall not apply where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or the building is equipped with smoke and heat vents in accordance with Clause 10.10.

27.10.5 Aggregate area of skylights.

The aggregate area of skylights shall not exceed 1/3 of the floor area of the room or space sheltered by the roof in which such skylights are installed where Class CC1 materials are utilized, and 1/4 of the floor area where Class CC2 materials are utilized.

Exception: The aggregate area limitations of light-transmitting plastic skylights shall be increased 100 percent beyond the limitations set forth in this clause where the building is equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 or the building is equipped with smoke and heat vents in accordance with Clause 10.10.

27.10.6 Separation.

Skylights shall be separated from each other by a distance of not less than 1219 mm (4 feet) measured in a horizontal plane.

Exceptions:

1. Buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1.

2. In Group R-3, multiple skylights located above the same room or space with a combined area not exceeding the limits set forth in Clause 27.10.4.

27.10.7 Location.

Where exterior wall openings are required to be protected in accordance with Clause 8.5, a skylight shall not be installed within 6 feet (1829 mm) of such exterior wall.

27.10.8 Combinations of roof panels and skylights.

Combinations of light-transmitting plastic roof panels and skylights shall be subject to the area and percentage limitations and separation requirements applicable to roof panel installations.

27.11 LIGHT-TRANSMITTING PLASTIC INTERIOR SIGNS

27.11.1 General.

Light-transmitting plastic interior signs shall be limited as specified in Clauses 27.6 and 27.11.2 through 27.11.4.

Exception: Light-transmitting plastic interior wall signs in covered and open mall buildings shall comply with Clause 4.2.6.4.
27.11.2 Maximum area.

The aggregate area of all light-transmitting plastics shall not exceed $2.23 \text{ m}^2$ (24 square feet).

Exception: In buildings equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, the aggregate area of light-transmitting plastics shall not exceed $9.29 \text{ m}^2$ (100 square feet), provided that all plastics are Class CC1 in accordance with Clause 27.6.4.

27.11.3 Separation.

Signs exceeding the aggregate area of Clause 27.11.2 shall be separated from each other by not less than 1219 mm (4 feet) horizontally and 2438 mm (8 feet) vertically.

27.11.4 Encasement.

Backs of wall-mounted signs and non-illuminated portions of all signs regulated by this clause shall be fully encased in metal.

27.12 PLASTIC COMPOSITES

27.12.1 General.

Plastic composites shall consist of either wood/plastic composites or plastic timber. Plastic composites shall comply with the provisions of this Code and with the additional requirements of Clause 27.12.

27.12.2 Labeling.

Plastic composite deck boards and stair treads, or their packaging, shall bear a label that indicates compliance with ASTM D7032 and includes the allowable load and maximum allowable span determined in accordance with ASTM D7032. Plastic composite handrails and guards, or their packaging, shall bear a label that indicates compliance with ASTM D7032 and includes the maximum allowable span determined in accordance with ASTM D7032.

27.12.3 Flame spread index.

Plastic composite deck boards, stair treads, handrails and guards shall exhibit a flame spread index not exceeding 200 when tested in accordance with ASTM E84 or with the test specimen remaining in place during the test.

Exception: Materials determined to be noncombustible in accordance with Clause 8.3.5.

27.12.4 Termite and decay resistance.

Where required by Clause 24.4.12, plastic composite deck boards, stair treads, handrails and guards containing wood, cellulosic or any other biodegradable materials shall be termite and decay resistant as determined in accordance with ASTM D7032.

27.12.5 Construction requirements.

Plastic composites meeting the requirements of Clause 27.12 shall be permitted to be used as exterior deck boards, stair treads, handrails and guards where combustible construction is permitted.

27.12.5.1 Span rating.

Plastic composites used as exterior deck boards shall have a span rating determined in accordance with ASTM D7032.

27.12.6 Plastic composite deck boards, stair treads, handrails and guards.

Plastic composite deck boards, stair treads, handrails and guards shall be installed in accordance with this Code and the manufacturer’s instructions.

27.13 FIBRE-REINFORCED POLYMER

27.13.1 General.

The provisions of this clause shall govern the requirements and uses of fibre-reinforced polymer in and on buildings and structures.

27.13.2 Labeling and identification.

Packages and containers of fibre-reinforced polymer and their components delivered to the job site shall bear the label of an approved agency showing the manufacturer’s name, product listing, product identification and information sufficient to determine that the end use will comply with the Code requirements.
27.13.3 Interior finishes.
Fibre-reinforced polymer used as interior finishes, decorative materials or trim shall comply with Part 9.

27.13.3.1 Foam plastic cores.
Fibre-reinforced polymer used as interior finish and that contains foam plastic cores shall comply with Part 9 and this part.

27.13.4 Light-transmitting materials.
Fibre-reinforced polymer used as light-transmitting materials shall comply with Clauses 27.6 through 27.11 as required for the specific application.

27.13.5 Exterior use.
Fibre-reinforced polymer shall be permitted to be installed on the exterior walls of buildings of any type of construction provided all the following conditions are met.

Conditions:

1. Compliance with Clause 27.3.5 is not required where all of the following conditions are met:

   1.1. The fibre-reinforced polymer shall not exceed an aggregate total of 20 percent of the area of the specific wall to which it is attached, and single architectural elements shall not exceed 10 percent of the area of the specific wall to which it is attached, and no contiguous sets of architectural elements shall not exceed 10 percent of the area of the specific wall to which they are attached.

   1.2. The fibre-reinforced polymer shall have a flame spread index of 25 or less. The flame spread index requirement shall not be required for coatings or paints having a thickness of less than 0.9 mm (0.036 inch) that are applied directly to the surface of the fibre-reinforced polymer.

2. Compliance with Clause 27.3.5 is not required where the fibre-reinforced polymer is installed on buildings that are 12 190 mm (40 feet) or less above grade and the following conditions are met:

   2.1. The fibre-reinforced polymer shall meet the requirements of this Code.

   2.2. Where the fire separation distance is 1524 mm (5 feet) or less, the area of the fibre-reinforced polymer shall not exceed 10 percent of the wall area. Where the fire separation distance is greater than 1524 mm (5 feet), the area of the exterior wall coverage using fibre-reinforced polymer shall not be limited.

   2.3. The fibre-reinforced polymer shall have a flame spread index of 200 or less. The flame spread index requirements do not apply to coatings or paints having a thickness of less than 0.9 mm (0.036 inch) that are applied directly to the surface of the fibre-reinforced polymer.

   2.4. Fire-blocking complying with Clause 8.18.2.6 shall be installed.

1.3. Fire-blocking complying with Clause 8.18.2.6 shall be installed.

1.4. The fibre-reinforced polymer shall be installed directly to a noncombustible substrate or be separated from the exterior wall by one of the following materials: corrosion-resistant steel having a minimum base metal thickness of 0.41 mm (0.016 inch) at any point, aluminum having a minimum thickness of 0.5 mm (0.019 inch) or other approved noncombustible material.
27.14 REFLECTIVE PLASTIC CORE INSULATION

27.14.1 General.

The provisions of this clause shall govern the requirements and uses of reflective plastic core insulation in buildings and structures. Reflective plastic core insulation shall comply with the requirements of Clause 27.14 and of Clause 27.14.3 or 27.14.4.

27.14.2 Identification.

Packages and containers of reflective plastic core insulation delivered to the job site shall show the manufacturer’s or supplier’s name, product identification and information sufficient to determine that the end use will comply with the Code requirements.

27.14.3 Surface-burning characteristics.

Reflective plastic core insulation shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450 when tested in accordance with ASTM E84. The reflective plastic core insulation shall be tested at the maximum thickness intended for use. Test specimen preparation and mounting shall be in accordance with ASTM E2599.

27.14.4 Room corner test heat release.

Reflective plastic core insulation shall comply with the acceptance criteria of Clause 803.1.1.1 when tested in accordance with ASTM E84 in the manner intended for use and at the maximum thickness intended for use.

PART 28: ELECTRICAL SYSTEMS AND ALLIED INSTALLATIONS

User note:

About this part: Electrical systems and components are integral to most structures; therefore it is necessary for the Code to address their installation and protection. Structures depend on electricity for the operation of many life safety systems including fire alarm, smoke control and exhaust, fire suppression, fire command and communication systems. Since power supply to these systems is essential, Part 28 addresses where standby and emergency power must be provided.

28.1 GENERAL

28.1.1 Scope.

The provisions of this part shall govern the design, construction, erection and installation of the electrical components, appliances, equipment and systems used in buildings and structures covered by this Code. The Code shall also govern the use and maintenance of electrical components, appliances, equipment and systems including alteration, repair, relocation, replacement and addition of electrical components, appliances, or equipment and systems.

28.2 DEFINITIONS AND CONVENTIONAL SYMBOLS

28.2.1 For the purpose of this Clause, the following definitions shall apply.

Accessory – A device, other than current using equipment, associated with such equipment or with the wiring on an installation.

Apparatus – Electrical apparatus including all machines, appliances and fittings in which conductors are used or of which they form a part.

Appliance – An item of current using equipment other than a luminaire or an independent motor.

Bunched – Cables are said to be 'bunched' when two or more are contained within a single conduit, duct, ducting, or trunking or, if not enclosed, are not separated from each other.

Cable – A length of single – insulated conductor (solid or stranded), or two or more such conductors, each provided with its own insulation, which are laid up together. The insulated conductor or conductors may or may not be provided with an overall mechanical protective covering.

Cable, Armoured – A cable provided with a wrapping of metal (usually in the
form of tape or wire) serving as a mechanical protection.

Cable, Flexible – A cable containing one or more cores, each formed of a group of wires, the diameters of the cores and of the wires being sufficiently small to afford flexibility.

Cable, Metal-Sheathed – An insulated cable with a metal sheath.

Cable, PVC Sheathed-Insulated – A cable in which the insulation of the conductor is a polyvinylchloride (PVC) compound; with PVC sheath also providing mechanical protection to the conductor core or cores in the cable.

Cable, Weatherproof – A cable so constructed that when installed in uncovered locations, it will withstand all kinds of weather variations (See below for definition of Weatherproofing).

Cable, ELPE – A cable in which the insulation of the conductor is cross-linked polythene and the mechanical protection is provided for the core or cores by a sheath of a poly chloride compound.

Ceiling Rose – A fitting (usually used to attach to the ceiling) designed for the connection between the electrical installation wiring and a flexible cord (which is in turn connected to a lampholder).

Circuit – An assembly of electrical equipment supplied from the same origin and protected against over-current by the same protective device(s). Certain types of circuit are categorized as follows:

(a) Category/Circuit – A circuit (other than a fire alarm or emergency lighting circuit) operating at low voltage and supplied directly from a mains supply system.
(b) Category 2 Circuit – With the exception of fire alarm and emergency lighting circuits, any circuit for telecommunication (for example, radio, telephone, sound distribution, intruder alarm, bell and call and data transmission circuits) which is supplied from a safety source.
(c) Category 3 Circuit – A fire alarm circuit or an emergency lighting circuit.

Circuit Breaker – A mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions and also of making, carrying for a specified abnormal circuit conditions such as those of short circuit.

NOTE – A Circuit breaker is usually intended to operate infrequently, although some types are suitable for frequent operation.

Circuit, Final Sub – An outgoing circuit connected to one-way distribution board and intended to supply electrical energy at one or more points to current, using appliances without the intervention of a further distribution board other than a one-way board. It includes all branches and extensions derived form that particular way in the board.

Cleat – An insulated incombustible support normally used for insulated cable.

Conductor, Aerial – Any conductor which is supported by insulators above the ground and is directly exposed to the weather.

NOTE – Four classes of aerial conductors are recognized:

a) Bare aerial conductors,
b) Covered aerial conductors,
c) Insulated aerial conductors, and
d) Weatherproof neutral-screened cable.

Conductor, Bare – A conductor not covered with insulating material.
Conductor, Earthed – A conductor with no provision for its insulation from earth.

Conductor, Insulated – A conductor adequately covered with insulating material of such quality and thickness as to prevent danger.

Conductor of a Cable or Core – The conducting portion consisting of a single wire or group of wires, assembled together and in contact with each other or connected in parallel.

Connector – The part of a cable coupler or of an appliance coupler which is provided with female contact and is intended to be attached to the flexible cable connected to the supply.

Connector Box or Joint Box – A box forming a part of wiring installation, provided to contain joints in the conductors of cables of the installations.

Connector for Portable Appliances – A combination of a plug and socket arranged for attachment to a portable electrical appliance or to a flexible cord.

Consumer’s Terminals – The ends of the electrical conductors situated upon any consumer’s premises and belong to him at which the supply of energy is delivered from the service line.

Cord, Flexible – A flexible cable having conductor of small cross-clausal area. Two flexible cords twisted together are known as twin ‘flexible cord’.

Core of a Cable – A single conductor of a cable with its insulation but not including any mechanical protective covering.

Cut-out – Any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a predetermined amount.

Damp Situation – A situation in which moisture is either permanently present or intermittently present to such an extent as to be likely to impair the effectiveness of an installation conforming to the requirements for ordinary situations.

Dead – A portion of the circuit (normally expected to carry a voltage) at or near about earth potential or apparently disconnected from any live system.

Direct Earthing System – A system of earthing in which the parts of an installation are so earthed as specified but are not connected within the installation to the neutral conductor of the supply system or to earth through the trip coil of an earth leakage circuit-breaker.

Distance Area or Resistance Area (for Earth Electrode only) – The area of ground (around an earth electrode) within which a voltage gradient measurable with ordinary commercial instruments exists when the electrode is being tested.

Discrimination (Over-Current Discrimination) – Co-ordination of the operating characteristics of two or more over-current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the others do not.

NOTES:

1. Protective devices should have discrimination so that only the affected part (minimum clause) of the circuit is isolated, even though a number of protective devices may be in the path of the over-current.

2. Distinction is made between series discrimination involving different over-current protective devices passing substantially the same over-current and network discrimination involving identical protective devices passing different
proportions of the over-current.

**Earth** – The conductive mass of the earth, whose electric potential at any point is conventionally taken as zero.

**Earth Continuity Conductor** – The conductor, including any clamp, connecting to the earthing lead or to each other those parts of an installation which are required to be earthed. It may be in whole or in part the metal conduit or the metal sheath or armour of the cables, or the special continuity conductor of a cable or flexible cord incorporating such a conductor.

**Earth Electrode** – A conductor or group of conductors in intimate contact with and providing an electrical connection to earth.

**Earth Fault** – Accidental connections of a conductor to earth when the impedance is negligible, the connection is called a dead earth.

**Earthing Lead** – The final conductor by which the connection to the earth electrode is made.

**Earth Leakage Circuit Breaker System** – A system of earthing in which the parts of an installation, specified, to be earthed are so earthed through one or more earth leakage circuit-breakers or relays.

**Enclosed Distribution Board** – An enclosure containing bus bars with one or more control and protected devices for the purpose of protecting, controlling or connecting more than one outgoing circuits fed form one or more incoming circuits.

**Exposed Metal** – All metal parts of an installation which are easily accessible other than:

(a) Parts separated from live parts by double insulation;
(b) Metal name-plates, screw heads, covers, or plates, which are supported on or attached or connected to substantial non-conducting material only in such a manner that they do not become alive in the event of failure of insulation of live parts and whose means of fixing do not come in contact with any internal metal; and

(c) Parts which are separated from live parts by other metal parts which are themselves earthed or have double insulation.

**Fire Survival Cable** – A cable which continues in service after exposure to a temperature of $900^\circ C$ for 20 min or $700^\circ C$ for 90 min.

**Fitting, lighting** – A device for supporting or containing a lamp or lamps (for example, fluorescent or incandescent) together with any holder, shade, or reflector, for example, a bracket, a pendant with ceiling rose, an electrolier, or a portable unit.

**Flameproof Enclosure** – An enclosure which will withstand without injury any explosion of inflammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith) and will prevent the transmission of flame which may ignite any inflammable gas that may be present in the surrounding atmosphere.

**Notes**

1. Hazardous areas are classified into different zones, depending upon the extent to which an explosive atmosphere could exist at that place. In such areas flame proof switchgear, fittings, accessories, have to be used/installed in flameproof enclosure.

2. An electrical apparatus is not considered as flameproof unless it complies with the
3. Other types of fittings are also in vogue in wiring installations, for example, 'increased safety'.

Flame Retardant Cable – Flame retardant cable with reduced halogen evaluation and smoke.

Fuse – A device that, by the fusion of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted when the current through it exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.

Fuse-Element – A part of the fuse-link designed to melt under the action of current exceeding some definite value for a definite period of time.

Harmonics (Current and Voltage) – All alternating current which is not absolutely sinusoidal is made up of a fundamental and a certain number of current harmonics which are the cause of its deformation (distortion) when compared to the theoretical sine-wave.

Inflammable – A material capable of being easily ignited.

Installation (Electrical), of Buildings – An assembly of associated electrical equipment to fulfil a specific purpose or purposes and having co-ordinated characteristics.

Insulated – Insulated shall mean separated from adjacent conducting material or protected from personal contact by a non-conducting substance or an air space, in either case offering permanently sufficient resistance to the passage of current or to disruptive discharges through or over the surface of the substance or space, to obviate danger or shock or injurious leakage of current.

Insulation, Basic – Insulation applied to live parts to provide basic protection against electric shock.

Note – Basic insulation does not necessarily include insulation used exclusively for functional purposes.

Insulation, Double – Insulation comprising both basic and supplementary insulation.

Insulation (Electrical) – Suitable non-conducting material, enclosing, surrounding or supporting as conductor.

Insulation, Reinforced – Single insulation applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard.

Note – The term ‘single insulation’ does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

Insulation, Supplementary – Independent insulation applied in addition to basic insulation in other to provide protection against electric shock in the event of a failure of basic insulation.

Linked Switch – Switches linked together mechanically so as to operate simultaneously or in definite sequence.

Live or Alive – Electrically charged so as to have a potential different from that of earth.

Locations, Industrial – Locations where tools machinery requiring electrical wiring are installed or manufacture or repair.

Locations, Non-Industrial – Locations other than industrial locations, and shall include residences, offices, shops,
showrooms, stores and similar premises requiring electrical wiring for lighting, or similar purposes.

**Miniature Circuit Breaker** – Mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions and also making carrying currents for specified times and automatically breaking currents under specified abnormal circuit conditions such as those of overload and short circuits.

**Multiple Earthed Neutral System** – A system of earthing in which the parts of an installation specified to be earthed are connected to the general mass of earth and, in addition, are connected within the installation to the neutral conductor of the supply system.

**Neutral Conductor** – Includes the neutral conductor of a three-phase four-wire system, the conductor of a single-phase or dc installation which is earthed by the supply undertaking (or otherwise at the source of the supply), and the middle wire or common return conductor of a three-wire dc or single-phase ac system.

**Plug** – A device, provided with contact pins, which is intended to be attached to a flexible cable, and which can be engaged with a socket outlet or with a connector.

**Point (in Wiring)** – A termination of the fixed wiring intended for the connection of current using equipment.

**Residual Current Circuit Breaker** – A mechanical switching device design to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual currents attains a giving value under specified conditions.

**Service** – The conductors and equipment required for delivering energy from the electric supply system to the wiring system of the premises served.

**Socket-Outlet** – Accessory having socket contacts designed to engaged with the pins of a plug and having terminals for the connection of cable(s).

**Switch** – A mechanical switching device capable of making, carrying and breaking current under normal circuit conditions, which may include specified operating overload conditions, and also of carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit.

**Switchboard** – An assembly of switchgear with or without instruments, but the term does not apply to a group of local switches in a final circuit.

**Switch Disconnectors** – A device used to pen (or close) a circuit when either negligible current is interrupted (or established) or when the significant change in the voltage across the terminals of each of the pole of the disconnectors occurs; in the open position it provides an isolating distance between the terminals of each pole.

**Switch Disconnecter Fuse** – A composite unit, comprising a switch with the fuse contained in or mounted on the moving member of the switch.

**Switchgear** – A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation,
transmission, distribution and conversion of electric energy.

**Usable Wall space** – A portion of a wall, except that occupied by a door in its normal open position, or occupied by a fire place opening, but excluding wall spaces which are less than 1m in extent measured along the wall at the floor line.

**Voltage, Extra Low (ELV)** – The voltage which does not normally exceed 50 V.

**Voltage, Low (LV)** – The voltage which normally exceeds 50 V but does not normally exceed 250 V.

**Voltage, Medium (MV)** – The voltage which normally exceeds 250 V but does not exceed 650 V.

**Voltage, High (HT, HV)** – The voltage which normally exceeds 650 V but less than or equal to 33 kV.

**Voltage, Extra High (EHT)** – The voltage, which normally exceeds 33 kV.

**Weatherproof** – Accessories, lighting fittings, current-using appliances and cables are said to be of the weatherproof type, if they are so constructed that when installed in open situation they will withstand the effects of rain, dust and temperature variations.

For definition of other terms reference may be made to accepted standards [8 – 2 (1)].

### 28.2.2 CONVENTIONAL SYMBOLS

The architectural symbols that are to be used in all drawings, wiring plans, etc for electrical installations in buildings shall be as given in this Code.

For other graphical symbols used in electrotechnology, reference may be made to good practice.

### 28.3 GENERAL REQUIREMENTS

#### 28.3.1 Conformity with Ghana Wiring Code.

The installation shall generally be carried out in conformity with the requirements of the Ghana Wiring Code.

#### 28.3.2 Materials

All materials, fittings, appliances, etc. used in electrical and allied installations, shall conform to this Building Code and other standards.

#### 28.3.3 Co-ordination with Local Supply Authority

a) In all cases, that is, whether the proposed electrical work is a new installation or extension of an existing one, or a modification involving major changes, the electricity supply undertaking shall be consulted about the feasibility, etc. at an early date.

b) **Addition to an Installation** – An addition, temporary or permanent, shall not be made to the authorized load of an existing installation, until it has been definitely ascertained that the current carrying capacity and the condition of existing accessories, conductors, switches, etc. affected, including those of the supply authority are adequate for the increased load. The size of the cable/conductor shall be suitably selected on the basis of the ratings of the protective devices. Ratings of protective devices and their types shall be based on the installed load, switching characteristics and power factor.

Load assessment and application of suitable diversity factor to estimate the full load current shall be made as a first step. This should be done for every circuit, submain and feeder. Power factor and efficiency of loads shall also be considered. Diversity factor assumed shall be based on one’s own experience. Allowance should be made for about 15 percent to 20 percent for extension in near future and the design circuit is calculated for each circuit and submain. The wiring system to be adopted should also be decided in accordance with the environmental requirements. The sizes of wiring cables are decided not merely to carry the load currents, but also to withstand thermal effects of
likely over currents and also ensure acceptance level of voltage drop.

28.3.4 Power Factor Improvement in Consumers’ Installation

28.3.4.1 Conditions of supply of electricity boards or licensees stipulate the lower-limit of power factor which is generally 0.85.

28.3.4.2 Principal causes of low power factor are many. For guidance to the consumers of electric energy who take supply at low and medium voltages for improvement of power factor, reference shall be made in accordance with good practice.

28.3.5 Execution of Work

Unless otherwise exempted under the appropriate rule of the Electricity Company of Ghana work of electrical installations shall be carried out by a licensed electrical contractor and under the direct supervision of a person holding a certificate of competency and by persons holding a valid permit issued and recognized by any State government.

28.3.6 Safety procedures and practices shall be kept in view during execution of the work in accordance with good practice.

28.4 PLANNING OF ELECTRICAL INSTALLATIONS

28.4.1 General

The design and planning of an electrical wiring installation involve consideration of all prevailing conditions, and is usually influenced by the type and requirement of the consumer. A competent electrical design engineer should be involved at the planning stage with a view to providing for an installation that will prove adequate for its intended purpose, and safe and efficient in its use. The information given in 3 shall also be kept in view.

28.4.1.1 The design and planning of an electrical wiring installation shall take into consideration, some or all of the following:

a) the type of supply, occupancy, envisaged load and the earthing arrangement available;

b) the atmospheric condition, such as cooling air temperature, moisture or such other conditions which are likely to affect the installation adversely;

c) the possible presence of inflammable or explosive dust, vapour or gas;

d) the degree of electrical and mechanical protection necessary;

e) the importance of continuity of service including the possible need for standy supply;

f) the probability of need for modification or future extension;

g) the probable operation and maintenance cost taking into account the electricity supply tariffs available;

h) the relative set of various alternative methods;

j) the need for radio and telecommunication interference suppression;

k) case of maintenance;

m) safety aspects;

n) energy conservation; and

p) the importance of proper discrimination between protective devices for continuity of supply and limited isolation of only the affected portion.

28.4.1.2 All electrical apparatus shall be suitable for the services these are intended for:

28.4.1.3 Co-ordination

Proper co-ordination and collaboration between the architect, civil engineer and the electrical and mechanical engineer shall be effected from the planning stage of the installation. The provisions that will be needed for the accommodation of substation, transformer, switch rooms, service cable ducts, rising mains and distribution cables, sub-distribution boards, openings and chases in floors and walls for all
required electrical installations, etc. shall be specified in advance.

28.4.1.4 Before starting wiring and installation of fittings and accessories, information should be exchanged between the owner of the building/architect/electrical contractor and the local supply authority in respect of tariffs applicable, types of apparatus that may be connected under each tariff, requirement of space for installing meters, switches, etc. and for total load requirements of lights, fans and power.

28.4.1.5 While planning an installation, consideration should be taken of the anticipated increase in the use of electricity for lighting, general purpose socket-outlet, kitchen heating, etc.

It is essential that adequate provision should be made for all the services which may be required immediately and during the intended useful life of the building, for the householder may otherwise be tempted to carry out extension of the installation himself or to rely upon use of multi-plug adopters and long flexible cords, both of which are not recommended.

28.4.2 Location and Requirement of Substation

Information on location and requirements of a substation should cover the following:

28.4.2.1 Location

a) The substation should preferably be located in separate building and could be adjacent to the generator room. If any, location of substation in the basement floors should be avoided, as far as possible.

b) The ideal location for an electrical substation for a group of buildings would be at the electrical load centre on the ground floor.

c) The floor level of the substation or switch room shall be above the highest flood level of the locality.

d) Generally the load centre would be somewhere between the geometrical centre and the air conditioning plant room, as air conditioning plant room would normally be the largest chunk of load, if the building is air conditioned.

e) Substations with oil filled equipment will require great consideration for the fire detection, protection and suppression. Oil cooled transformers require a suitable soak pit with gravity flow to contain the oil in the event of the possibility of oil spillage from the transformer on its failure. Substations with oil filled equipment shall not be located in any floor other than the ground floor or a semi-basement. Such substations with high oil content may be housed in a separate service building or a substation building, which is not the part of a multi-storeyed building.

f) In case electric substation has to be located within the main multi-storeyed building itself for unavoidable reasons, then it should be located on the floor close to ground level, but shall have direct access from the street for operation of the equipments. The provision for installation and removal of substation equipments may be provided from inside the building.

g) Substations located within a multi-storeyed building shall not have oil filled transformers, even if it is at the ground level. Substations with very little combustible material, such as a dry type transformer, with Vacuum (or SF$_6$) HT switchgear and ACB or MCCB for MV can be located in the basement as well as upper floors in a building with high load density in the upper floors. (Some functional buildings such as hospitals, air traffic control towers, computer centres are likely to have high loading in a few upper floors and in such cases, it may be preferable to provide oil-free substations at upper levels. This measure will decrease the current flow at various points, thereby contributing to reduction of vulnerability to fire).

h) The power supply control to any such substation or transformer (located at basement levels or upper floors) shall be from a location on ground floor/first basement level having direct access from outside so that in case of fire, the electricity supply can be easily disconnected.
j) Oil filled transformers may be used only in substations located in separate single or two storeyed service buildings outside the main building structure and there shall at least 6 meter clear distance between the adjoining buildings and substation such that fire tender is able to pass between the two structures.

k) If dry type transformer is used, it may be located adjacent to medium voltage switchgear in the form of unit type substation. No separate room or fire barrier for the transformer is required, in a substation with oil free equipment. In such a case the room size will decrease. Layout of equipment has to keep the requirement that any one piece of equipment or sub-assembly can be taken out of service and out of the installed location, while keeping the remaining system in service.

m) The emergency power supply (such as generating sets) should not be allowed to be installed above ground floor or below first basement level of building. There shall be provision of separate direct escape and entry into these areas from outside so that in case of fire, electrical supplies can be disconnected to avoid additional loses which may be caused due to electrical supply, present at the time of fire.

n) For transformers having large oil content (more than 2,000 litres). Rules of the Electricity Company of Ghana (ECG) as amended from time to time shall apply.

p) Facility for connections from substation to adjoining building to feed essential emergency load in that building, such as escape route lighting, fire or sprinkler pumps, emergency communication systems shall be provided. Similarly, the essential emergency load switchboard of this building or building complex should be so as to be capable of receiving power for such loads from the adjoin building or building complex, with adjoining building or building complex, its own substation/DG sets shut off due to crisis conditions such as fire.

q) The availability of power lines nearby may also be kept in view while deciding the location of the substation.

r) For detailed information regarding location of transformers reference may be made to good practice,

s) All door openings from substation, electrical rooms, etc. should open towards outside.

t) For acoustical enclosures/treatment reference may be made to: 'Building Services- Acoustics, Sound Insulation and Noise Control'.

28.4.2.2 Type of building for substations

The substations enclosure that is, walls, floor, ceiling, openings, doors, etc. shall have a 2 hour fire rating.

28.4.2.3 Layout of substation

In allocating the area of substation, it is to be noted that the flow of electric power is from supply company’s room to HV room, then to transformer and finally to the medium voltage switchgear room. The layout of the room shall be in accordance with this flow, so as to optimize the cables, bus-trunking etc. Visibility of equipment controlled from the operating point of the controlling switchgear is also a desirable feature, though it may not be achievable in case of large substations.

28.4.2.4 Room/spaces required

Generally the following rooms/spaces are required in a substation:

a) Supply company’s switchgear from and/or space for meters.

b) Capacity and Size – The capacity of a substation depends upon the area of the building and its type. The capacity of substation may be determined based on the following load requirements.
<table>
<thead>
<tr>
<th>Purpose of final circuit fed from conductors or switchgear to which diversity applies</th>
<th>Individual household installations, including individual dwelling of a Block</th>
<th>Type of premises small, shops, stores offices and business</th>
<th>Type of premises small hotels, boarding houses, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>66% of total demand</td>
<td>90% of total current demand</td>
<td>75% of total current demand</td>
</tr>
<tr>
<td>Heating and power</td>
<td>80% of total current demand up to 10A + 40% of any current demand in excess of 10A</td>
<td>80% full load of largest appliance +60% of remaining appliances</td>
<td>80% full load of largest appliance + 60% of second largest appliances +40% of remaining appliances</td>
</tr>
<tr>
<td>Cooking appliances</td>
<td>10A +30% full load of connected cooking appliances in excess of 10A + 5A if socket-outlet incorporated in unit.</td>
<td>80% full load of largest appliance +60% full load of second largest appliance +50% full load of remaining appliances</td>
<td>80% of largest appliance +60% of full load of second largest appliance +50% full load of remaining appliances</td>
</tr>
<tr>
<td>Motor (other than lift motors which are subject to special consideration)</td>
<td></td>
<td>80% full load of largest motor +60% full load of second largest motor +50% full load of remaining motors</td>
<td>80% full load of largest motor +50% full load of remaining motors</td>
</tr>
<tr>
<td>Water heater</td>
<td>80% full load of largest appliance +50% of second largest appliance +25% full load of remaining appliances</td>
<td>80% full load of largest appliance +60% of second largest appliance +25% full load of remaining appliances</td>
<td>80% full load of largest appliance +60% of second largest appliance +25% full load of remaining appliances</td>
</tr>
<tr>
<td>Floor warming installations</td>
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<td>Water heaters thermal storage space heating installations</td>
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<td>50%</td>
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<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>----------------------------------------</td>
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<tr>
<td>Standard arrangements of final circuits</td>
<td>80% of current demand of largest circuit</td>
<td>80% of current demand of largest circuit</td>
<td>80% of current demand of largest point of</td>
</tr>
<tr>
<td>in accordance with IS 732</td>
<td>+40% of current demand of every other circuit</td>
<td>+50% of current demand of every other circuit</td>
<td>+60% of current demand of every other point of</td>
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<td></td>
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<tr>
<td>Socket outlets other than those</td>
<td>80% of current demand of largest point of</td>
<td>80% of current demand of largest point of</td>
<td>80% of current demand of largest point of</td>
</tr>
<tr>
<td>included above and stationary</td>
<td>+40% of current demand of every other point of</td>
<td>+60% of current demand of every other point of</td>
<td>+40% of current demand of every other point of</td>
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<tr>
<td>equipment other than those listed</td>
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<td>above</td>
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</table>

Notes:
1. For the purpose of the table an instantaneous water heater is deemed to be a water heater of any loading which heats water only while the tap is turned on and therefore uses electricity intermittently.
2. It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity.

After calculating the electrical load on the above basis, a load factor of 70-90 percent is to be applied to arrive at the minimum capacity of substation. The area required for substation and transformer room for different capacities is given in Annex C for general guidance. For reliability, it would be necessary to split the load into more than one transformer and also provide for standby transformer as well as multiple sources, bus-clause, etc.

c) High Voltage Switch Room – In case of substation having one transformer and one source of supply, the owner is required to provide one high voltage switch. In case of single point supply with two or more transformers the number of switch required will be one for incoming supply and one for each transformer. In case of duplicate supply two switches shall be provided with mechanical/electrical in locking arrangement where necessary in cables with switches. In case the number of incoming and outgoing switches exceed five, bus coupler of suitable capacity should invariably be provided. The floor area required in case of a single switch is roughly 4m x 4m and for every additional switch the length would be increased by 1m.

d) Facility for connection from substation of adjoining building to feed emergency loads shall be permitted for feeding escape route and signage lighting as well as selected clause of the fire protection system. Similarly on a reciprocal basis facility to feed the adjoining building for such emergency loads may be provided by necessary switchgear.

e) Medium Voltage Switch Room – The floor area required in respect of medium voltage switchgear room may be determined keeping in view the number and type of incoming/outgoing bus coupler switches including likely expansion in future.

f) Room for Standby Generator – It is preferable to install the standby generator in service building. If installed in main building it shall be at the ground floor or at the semi basement, alternatively, in the first basement with facilities for forced ventilation. Adequate space shall be
provided for storing of fuel. Compartmentation for fire protection with detection and first-aid protection measures is essential. Different type of requirements exist for the diesel engine and generator for the oil storage area and for the switchgear.

g) Facilities including space at appropriate positions, relative to the location of the installed equipment has to be kept in the layout design for removal of equipment or sub-assemblies for repair or maintenance. When it is located, other than the ground level with direct equipment access, a hatch or ramp shall be required.

h) Other environmental requirements under the provisions of Environment Protection Rules, 1986 as amended time-to-time shall be taken into account form the aspect of engine emissions including regarding the height of exhaust pipe and permitted noise levels/noise control.

j) The capacity of standby generating set shall be chosen on the basis of essential light load, essential air conditioning load, essential equipment load and essential services load, such as one lift out of the bank of lifts, one or all water pumps, etc. Having chosen the capacity and number of generating sets, required space may be provided for their installation (See Annex D for general guidance).

k) The generating set should preferably be housed adjacent to MV switchgear in the substation building to enable transfer of electrical load quickly as well as to avoid transfer of vibration and noise to the main building. Acoustics lining of the room shall be in line with the requirements of central Pollution Control Board (CPCB). If DG Set is located outdoor, it shall be housed in acoustics enclosure. The generator house should have proper ventilation, fire fighting equipment, etc.

l) Requirements of room

1) The areas given above in respect of the different categories of rooms holds good if they are provided with windows and independent access doors in accordance with local regulations.

2) All the rooms shall be provided with partitions up to the ceiling and shall have proper ventilation. Special care should be taken to ventilate the transformer rooms and where necessary louvers at lower level and exhaust fans at higher level shall be provided at suitable locations.

3) In order to prevent storm water entering the transformer and switch rooms through the soak-pits, the floor level, the substation shall be at least 15 cm above the highest flood water level that may be anticipated in the locality. Also, facility shall be provided for automatic removal of water.

4) The minimum height of high voltage switchgear room shall be 3.6m below the soffit of the beam.

m) Fire compartmentation – It is advisable to provide fire compartmentation of buildings and segregation of associated wiring. Bus-bar trunking of horizontal and vertical distribution type in place of cable based distribution system shall be used.

28.4.3 Location of switch room

In large installations other than where a substation is provided, a separate switch room shall be provided; this shall be located as closely as possible to the electrical load centre preferably near the entrance of the building on the ground floor or on the first basement level, and suitable ducts shall be laid with minimum number of bends from the points of entry of the main supply cable to the position of the main switchgear. The switch room shall also be placed in such a position that rising ducts may readily be provided therefrom to the upper floors of the building in one straight vertical run. In larger buildings, more than one rising duct may be required and then horizontal ducts may also be required for running cables from the switch room to the foot of each rising main. Such cable ducts shall be either be reserved for the electrical services only or provided with a means of segregation for medium and low voltage installations, such as call-bell systems; telephone installations, fire detection and alarm system, announcement or public address system. Cables for essential emergency
services such as those related to fire detection, alarm and announcement should use either metal conduit in addition to physical segregation room power cables or use fire survival cables, so that the service is maintained even in the event of a fire at least for a period of about 20 min.

28.4.4 Location and requirements of distribution panels

The electrical control gear distribution panels and other apparatus, which are required on each floor may conveniently be mounted adjacent to the rising mains, and adequate space should be provided at each floor for this purpose.

28.4.5 Substation safety

The owner or the operator of any substation shall be collectively and severally be responsible for any lapse or neglect leading to an accident or an incidence of an avoidable abnormality and shall take care of the safety requirements as follows:

a) Enclose the substations where necessary to prevent, so far as is reasonably practicable, danger or unauthorized access;

b) Enclose any part of the substation, which is open to the air and contains live equipment which is not encased, with a fence or wall not less than 2.4m in height to prevent, so far as is reasonably practicable, danger or unauthorized access;

c) Ensure that, so far as is reasonably practicable, there are at all times displayed:

1) Sufficient safety signs of such size and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances;

2) A notice which is placed in a conspicuous position and which gives the location or identification of the substation, the name of each generator or distributor who owns or operates the substation equipment making up the substation and the telephone number where a suitably qualified person appointed for this purpose by the generator or distributor will be inconstant attendance; and

3) Such other signs, which are of such size and placed in such positions, as are necessary to give due warning of danger having regard to the siting of, the nature of, and the measures taken to ensure the physical security of, the substation equipment; and

d) Take all reasonable precautions to minimize the risk of fire associated with the equipment.

28.4.6 Overhead lines, wires and cables

28.4.6.1 Height requirement

While overhead lines may not be relevant within buildings, regulations related to overhead lines are of concern from two different angles.

a) Overhead lines may be required in building complexes, though use of underground cables is the preferred alternative.

b) Overhead lines may be passing through the site of a building. In such a case the safety aspects are important for the construction activity in the vicinity of the overhead line as well as portions of low height buildings that may have to be constructed below the overhead lines.

For minimum distance (vertical and horizontal) of electric lines/wires/cables from buildings, reference may be made to Part 3 ‘Development Control Rules and General Requirements’.

c) Any person responsible for erecting an overhead line will keep informed the authority(s) responsible for services in
that area for telecommunication, gas distribution, water and sewerage network, roads so as to have proper co-ordination to ensure safety. He shall also publish the testing, energizing programme for the line in the interests of safety.

28.4.6.2 Position, insulation and protection of overhead lines

Any part of an overhead line which is not connected with earth and which is not ordinarily accessible shall be supported on insulators or surrounded by insulation.

Any part of an overhead line which is not connected with earth and which is ordinarily accessible shall be:

a) Made dead; or
b) So insulated that it is protected, so far it is reasonably practicable, against mechanical damage or interference; or
c) Adequately protected to prevent danger.

Any person responsible for erecting a building or structure which will cause any part of an overhead line which is not connected with earth to become ordinarily accessible shall give reasonable notice to the generator or distributor who owns or operates the overhead line of his intention to erect that building or structure.

Any bare conductor not connected with earth, which is part of a low voltage overhead line, shall be situated throughout its length directly above a bare conductor which is connected with earth.

No overhead line shall, so far as is reasonably practicable, come so close to any building, tree or structure as to cause danger.

In this regulation the expression “ordinarily accessible” means the overhead line could be reached by hand if any scaffolding, ladder or other construction was erected or placed on/in, against or near to a building or structure.

28.4.6.3 Precautions against access and warnings of dangers

Every support carrying a high voltage overhead line shall, if the circumstances reasonably require, be fitted with devices to prevent, so far it is reasonably practicable, any unauthorized person from reaching a position at which any such line would be a source of danger.

Every support carrying a high voltage overhead line, and every support carrying a low voltage line incorporating bare phase conductors, shall have attached to it sufficient safety signs and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances.

Poles supporting overhead lines near the road junctions and turnings shall be protected by a masonry or earth fill structure or metal barricade, to prevent a vehicle from directly hitting the pole, so that the vehicle, if out of control, is restrained from causing total damage to the live conductor system, likely to lead to a hazardous condition on the road or foot path or building.

28.4.6.4 Fitting of insulators to stay wires

Every stay wire which forms part of, or is attached to, any support carrying an overhead line incorporating bare phase conductors (except where the support is a lattice steel structure or other structure entirely of metal and connected to earth) shall be fitted with an insulator no part of which shall be less than 3m above ground or above the normal height of any such line attached to that support.

28.4.7 Maps of underground networks

28.4.7.1 Any person or organization or authority laying cables shall contact authority in charge of that area and find out the layout of:

a) water distribution pipe lines in the area;
b) sewage distribution network;
c) telecommunication network, and
d) gas pipeline network and plan the cable network in such a manner that the system is compatible, safe and noninterfering either during its installation or during its operation and maintenance. Plan of the proposed cable installation shall be brought to the notice of the other authorities referred above.
28.4.7.2 Suitable cable markers and danger sign as would be appropriate for the safety of the workmen of any of the systems shall be installed along with the cable installation. Notification of testing and energization of the system shall also be suitably published for ensuring safety.

28.4.7.3 Any person or organization or authority laying cables shall have and, so far it is reasonably practicable, keep up to date, a map or series of maps indicating the position and depth below surface level of all networks or parts there for which the owns or operates.

Any map prepared or kept shall be available for inspection by any of the municipal authority, other service providers, general public provided they have a reasonable cause for requiring to inspect any part of the map.

28.5 LIGHTING

28.5.1 Principles of lighting

28.5.1.1 Aims of good lighting

Good lighting is necessary for all buildings and has three primary aims. The first aim is to promote work and other activities carried out within the building; the second aim is to promote the safety of the people using the building; and the third aim is to create, in conjunction with the structure and decoration, a pleasing environment conducive to interest of the occupants and a sense of their well-being.

28.5.1.1.1 Realization of these aims involves:

a) careful planning of the brightness and colour pattern within both the working areas and the surroundings so that attention is drawn naturally to the important areas, detail is seen quickly and accurately and the room is free from any sense of gloom or monotony (see 9.4.1.3);

b) using directional lighting where appropriate to assist perception of task detail and to give good modeling;

c) controlling direct and reflected glare from light sources to eliminate visual discomfort;

d) in artificial lighting installations, minimizing flicker from certain types of lamps and paying attention to the colour rendering properties of the light;

e) correlating lighting throughout the building to prevent excessive differences between adjacent areas so as to reduce the risk of accidents; and

f) installation of emergency lighting systems, where necessary.

28.5.1.2 Planning the brightness pattern

The brightness pattern seen within an interior maybe considered as composed of three main parts — the task itself, immediate background of the task and the general surroundings of walls, ceiling, floor, equipment and furnishings.

28.5.1.2.1 In occupations where the visual demands are small, the levels of illumination derived from a criterion of visual performance alone maybe too low to satisfy the other requirements. For such situations, therefore, illuminance recommendations are based on standards of welfare, safety and amenity judged appropriate to the occupations; they are also sufficient to give these tasks brightness which ensures that the visual performance exceeds the specified minimum. Unless there are special circumstances associated with the occupation, it is recommended that the illuminance of all working areas within a building should generally be 150 lux, even though the visual demands of the occupation might be satisfied by lower values.

28.5.1.2.2 Where work takes place over the whole utilizable area of room, the illumination over that area should be reasonably uniform and it is recommended that the uniformity ratio (minimum illuminance divided by average illuminance levels) should be not less than 0.7 for the working area.

28.5.1.2.3 When the task brightness appropriate to an occupation has been determined, the brightness of the other parts of the room should be planned to give a proper emphasis to visual comfort and interest. A general guide for the brightness relationship within the normal field of vision should be as follows:

a) For high task brightness Maximum (above 100 cd/m²):
1) Between the visual task 3 to 1 and the adjacent areas like table tops.
2) Between the visual task 10 to 1 and the remote areas of the room.

b) For low and medium task brightness (below 100 cd/m²):
The task should be brighter than both the background and the surroundings; the lower the task brightness, the less critical is the relationship.

### 28.5.1.3 Recommended values of illuminance

Table 3 gives recommended values of illuminance commensurate with the general standards of lighting described in this clause and related to many occupations and buildings; These are valid under most of the conditions whether the illumination is by daylighting, artificial lighting or a combination of the two. The great variety of visual tasks makes it impossible to list them all and those given should be regarded as representing types of task.

#### 28.5.1.3.1 The different locations and tasks are grouped within the following four clauses:

a) industrial buildings and process;
b) offices, schools and public buildings;
c) surgeries and hospitals; and
d) hotels, restaurants, shops and homes.

#### 28.5.1.3.2 The illumination levels recommended in Table 4 are those to be maintained at all time on the task. As circumstances maybe significantly different for different interiors used for the same application or for different conditions for the same kind of activity, a range of illuminances is recommended for each type of interior or activity instead of a single value of illuminance. Each range consists of three successive steps of the recommended scale of illuminances. For working interiors the middle value of each range represents the recommended service illuminance that would be used unless one or more of the factors mentioned below apply.

##### 28.5.1.3.2.1 The higher value of the range should be used when:

a) unusually low reflectance or contrasts are present in the task;
b) errors are costly to rectify;
c) visual work is critical;
d) accuracy or higher productivity is of great importance; and
e) the visual capacity of the worker makes it necessary.

**28.5.1.3.2.2** The lower value of the range may be used when:

a) reflectance or contrast are unusually high;
b) speed and accuracy is not important; and
c) the task is executed only occasionally.

#### 28.5.1.3.3 Where a visual task is required to be carried out throughout an interior, general illumination level to the recommended value on the working plane is necessary; where the precise height and location of the task are not known or cannot be easily specified, the recommended value is that on horizontal plane 850 mm above floor level.

**Note:** For an industrial task, working plane for the purpose of general illumination levels is that on a work place which is generally 750 mm above the floor level. For certain purposes, such as viewing the objects of arts, the illumination levels recommended are for the vertical plane at which the art pieces are placed.

#### 28.5.1.3.4 Where the task is localized, the recommended value is that for the task only; it need not, and sometimes should not, be the general level of illumination used throughout the interior. Some processes, such as industrial inspection process, call for lighting of specialized design, in which case the level of illumination is only one of the several factors to be taken into account.

### 28.5.1.4 Glare

Excessive contrast or abrupt and large changes in brightness produce the effect of glare. When glare is present, the efficiency of vision is reduced and small details or subtle changes in scene cannot be perceived. It may be:

a) direct glare due to light sources within the field of vision;
b) reflected glare due to reflections from light sources or surfaces of excessive brightness; and
c) veiling glare where the peripheral field is comparatively very bright.
28.5.1.4.1 An example of glare sources in daylighting is the view of the bright sky through a window or skylight, especially when the surrounding wall or ceiling is comparatively dark or weakly illuminated. Glare can be minimized in this case either by shielding the open sky from direct sight by louvers, external hoods or deep reveals, curtains or other shading devices or by cross lighting the surroundings to a comparable level. A gradual transition of brightness from one portion to the other within the field of vision always avoids or minimizes the glare discomfort.

28.5.1.5 Lighting for movement about a building

Most buildings are complexes of working areas and other areas, such as passages, corridors, stairways, lobbies and entrances. The lighting of all these areas should be properly correlated to give safe movement within the building at all times.

28.5.1.5.1 Corridors, passages and stairways

Accidents may result if people leave a well-lighted working area and pass immediately into corridors or on to stairways where the lighting is inadequate, as the time needed for adaptation to the lower level may be too long to permit obstacles or the treads of stairs to be seen sufficiently quickly. For the same reason, it is desirable that the illumination level of rooms which open off a working area should be fairly high even though the rooms may be used only occasionally.
Table 3: Recommended values of Illuminance (Clause 28.5.1.3)

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<td></td>
<td>Mixer drum, fan house, screen houses, coolers, transfer stations</td>
<td>100-150-200</td>
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<td>4.1.2</td>
<td>Furnaces, cupola:</td>
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<td>4.1.2.2</td>
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<td>4.1.2.3</td>
<td>Conveyor galleries, walkways</td>
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<td>4.2</td>
<td>Steel Making</td>
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<td>Electric melting shops</td>
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<td>4.2.2</td>
<td>Basic oxygen steel making plants</td>
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<td>Convertor floor, treating bay</td>
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<td>4.3</td>
<td>Metal Forming and Treatment</td>
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<td>Ingot stripping, soaking pits, annealing and heat treatment bays, acid recovery plant Picking and cleaning bays, roughing mills, cold mills, finishing mills, tinning and galvanizing lines, cut up and rewind lines</td>
<td>150-200-300</td>
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<td>Wire mills, product finishing, steel inspection and treatment</td>
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<td>4.3.6</td>
<td>Inspection of tin plate, stainless steel, etc</td>
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<td>Foundries</td>
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<td>Rough moulding, rough core making</td>
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<td>Forges (Severe vibration is likely to occur)</td>
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8 ELECTRICAL AND ELECTRONIC ENGINEERING

8.1 Electrical Equipment Manufacture

8.1.1 Manufacture of cables and insulated wires, winding, varnishing and immersion of coils, assembly of large machines, simple assembly work

8.1.2 Medium assembly, for example, telephones, small motors

8.1.3 Assembly of precision components, for example, telecommunication equipment, adjustment, inspection and calibration

8.1.4 Assembly of high precision parts

8.2 Electronic Equipment Manufacture

8.2.1 Printed circuit board

8.2.1.1 Silk screening

8.2.1.2 Hand insertion of components, soldering

8.2.1.3 Inspection

8.2.1.4 Assembly of wiring harness, cleaning harness, testing and calibration

8.2.1.5 Chassis assembly

8.2.2 Inspection and testing

8.2.2.1 Soak test

8.2.2.2 Safety and functional tests

9 FOOD, DRINK AND TOBACCO

9.1 Slaughter Houses

9.1.1 General

9.1.2 Inspection

9.2 Canning, Preserving and Freezing

9.2.1 Grading and sorting of raw materials

Lamp of colour rendering group 1A or 1B will be required, if colour judgement is required
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<td>Canned and bottled goods</td>
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<td>Inspection</td>
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<td>LEATHER INDUSTRY</td>
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<td>Mending, hand finishing</td>
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<td>Boot and Shoe Manufacture</td>
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<td>TIMBER AND FURNITURE</td>
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### 14 PAPER AND PRINTING

| 14.1    | Paper Mills | | | |
| 14.1.1  | Pulp mills, preparation plants | 200-300-500 | 3 | |
| 14.1.2  | Paper and board making | | | |
| 14.1.2.1 | General | 200-300-500 | 3 | |
| 14.1.2.2 | Automatic process | 150-200-300 | 3 | |
| 14.1.2.3 | Inspection, sorting | 300-500-750 | 1 | |
| 14.1.3  | Paper converting processes | | | |
| 14.1.3.1 | General | 200-300-500 | 3 | |
| 14.1.3.2 | Associated printing | 300-500-750 | 2 | |
| 14.2    | Printing Works | | | |
| 14.2.1  | Type foundries | | | |
| 14.2.1.1 | Matrix making, dressng type, hand and machine coating | 200-300-500 | 3 | |
| 14.2.1.2 | Front assembly, sorting | 500-750-1000 | 2 | Dimming may be required |
| 14.2.2  | Composing rooms | | | |
| 14.2.2.1 | Hand composing, imposition and distribution | 500-750-1000 | 1 | |
| 14.2.2.2 | Hot metal keyboard | 500-750-1000 | 1 | |
| 14.2.2.3 | Hot metal cutting | 200-300-500 | 2 | |
| 14.2.2.4 | Photo composing keyboard or setters | 300-500-750 | 1 | |
| 14.2.2.5 | Paste up | 500-750-1000 | 1 | |
| 14.2.2.6 | Illuminated tables — general lighting | 200-300-500 | | |
| 14.2.2.7 | Proof presses | 300-500-750 | 2 | |
| 14.2.2.8 | Proof reading | 500-750-1000 | 1 | |
| 14.2.3  | Graphic reproduction | | | |
| 14.2.3.1 | General | 300-500-750 | 2 | Local lighting may be appropriate |
| 14.2.3.2 | Precision proofing, retouching, etching | 750-1000-1500 | 1 | |
| 14.2.3.3 | Colour reproduction and inspection | 750-1000-1500 | 1 | |
| 14.2.4  | Printing machine room | | | |
| 14.2.4.1 | Presses | 300-500-750 | 2 | |
| 14.2.4.2 | Premake ready | 300-500-750 | 2 | |
| 14.2.4.3 | Printed sheet inspection | 750-1000-1500 | 1 | |
| 14.2.5  | Binding | | | |
| 14.2.5.1 | Folding, pasting, punching and stitching | 300-500-750 | 2 | |
| 14.2.5.2 | Cutting, assembling, embossing | 500-750-1000 | 2 | |

### 15 PLASTIC AND RUBBER

<p>| 15.1    | Plastic Products | | | |
| 15.1.1  | Automatic plant | | | |</p>
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<td>Control platforms</td>
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<td>Stock preparation — plasticizing, milling</td>
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16 DISTRIBUTION AND STORAGE

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<td>Unpacking, sorting</td>
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<td>3</td>
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<td>Small item rack storage</td>
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<td>Issue counter, records, storeman’s desk</td>
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<td>Warehouses and Bulk Stores</td>
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17 COMMERCE

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<td>—</td>
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<tr>
<td>20.4.16.1</td>
<td>General</td>
<td>200-300-500</td>
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<tr>
<td>20.4.16.2</td>
<td>Waiting rooms</td>
<td>100-150-200</td>
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<tr>
<td>20.4.17</td>
<td>Dental surgeries</td>
<td>—</td>
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<tr>
<td>20.4.17.1</td>
<td>Chair</td>
<td>Special lighting</td>
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<td>(1)</td>
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<tr>
<td>20.4.17.2 Laboratories</td>
<td></td>
<td>300-500-750</td>
<td></td>
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<tr>
<td>20.4.18 Consulting rooms</td>
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<tr>
<td>20.4.18.1 General</td>
<td></td>
<td>200-300-500</td>
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<td></td>
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<tr>
<td>20.4.18.2 Desk</td>
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<td>300-500-750</td>
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<td>20.4.18.3 Examination couch</td>
<td></td>
<td>300-500-750</td>
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<tr>
<td>20.4.18.4 Ophthalmic wall and near-vision charts</td>
<td></td>
<td>300-500-750</td>
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<tr>
<td>20.5 Hotels</td>
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<tr>
<td>20.5.1 Entrance halls</td>
<td></td>
<td>50-190-150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.5.2 Reception, cashier's and porters' desks</td>
<td></td>
<td>200-300-500</td>
<td></td>
<td></td>
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<tr>
<td>20.5.3 Bars, coffee base, dining rooms, grill rooms, restaurants, lounges</td>
<td></td>
<td>50-200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.5.4 Cloak rooms, baggage rooms</td>
<td></td>
<td>50-190-150</td>
<td></td>
<td></td>
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<tr>
<td>20.5.5 Bed rooms</td>
<td></td>
<td>30-50-100</td>
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<tr>
<td>20.5.6 Bathroom</td>
<td></td>
<td>50-190-150</td>
<td></td>
<td></td>
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<tr>
<td>20.5.7 Food preparation and stores, cellars, lifts and corridors</td>
<td></td>
<td></td>
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<tr>
<td>20.6 Libraries</td>
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<td></td>
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<td></td>
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<tr>
<td>20.6.1 Lending library</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20.6.1.1 General</td>
<td></td>
<td>200-300-500</td>
<td>1</td>
<td></td>
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<tr>
<td>20.6.1.2 Counters</td>
<td></td>
<td>300-500-750</td>
<td>1</td>
<td></td>
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<tr>
<td>20.6.1.3 Bookshelves</td>
<td></td>
<td>100-150-200</td>
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<td>20.6.1.4 Reading rooms</td>
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<td>200-300-500</td>
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<td>20.6.1.5 Reading tables</td>
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<tr>
<td>20.6.2 Catalogues</td>
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<tr>
<td>20.6.2.1 Card</td>
<td></td>
<td>100-150-200</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>20.6.2.2 Microfiche/Visual display units</td>
<td></td>
<td>100-150-200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.6.3 Reference libraries</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20.6.3.1 General</td>
<td></td>
<td>200-300-500</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20.6.3.2 Counters</td>
<td></td>
<td>300-500-750</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20.6.3.3 Bookshelves</td>
<td></td>
<td>100-150-200</td>
<td>2</td>
<td></td>
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<tr>
<td>20.6.3.4 Study tables, carrels</td>
<td></td>
<td>300-500-750</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20.6.3.5 Map room</td>
<td></td>
<td>200-300-500</td>
<td>1</td>
<td></td>
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<tr>
<td>20.6.4 Display and exhibition areas</td>
<td></td>
<td>200-300-500</td>
<td></td>
<td></td>
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<tr>
<td>20.6.4.2 Exhibit sensitive to light, for example, pictures, prints, rare books in archives</td>
<td></td>
<td>50 to 150</td>
<td></td>
<td></td>
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<tr>
<td>20.6.5 Library workrooms</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>20.6.5.1 Book repair and binding</td>
<td></td>
<td>300-500-750</td>
<td></td>
<td></td>
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<tr>
<td>20.6.5.2 Catalogue and sorting</td>
<td></td>
<td>300-500-750</td>
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<td></td>
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<tr>
<td>20.6.5.3 Remote book stores</td>
<td></td>
<td>100-150-200</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>20.7 Museums and Art Galleries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.7.1 Exhibits insensitive to light</td>
<td></td>
<td>200-300-500</td>
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<td></td>
</tr>
<tr>
<td>20.7.2 Light sensitive exhibits, for example, oil and temper paints, undyed leather, bone, ivory, wood, etc</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.7.3 Extremely light sensitive exhibits, for example, textiles, water colours, prints and drawings, skins, botanical specimens, etc</td>
<td></td>
<td>50</td>
<td></td>
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</tr>
<tr>
<td>20.7.4 Conservation studies and workshops</td>
<td></td>
<td>300-500-750</td>
<td></td>
<td></td>
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<tr>
<td>20.8 Sports Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Multi-purpose sports halls</td>
<td>300-750</td>
<td>—</td>
<td>—</td>
<td>This lighting system should be sufficiently flexible to provide lighting suitable for the variety of sports and activities that take place in sports halls. Higher illuminance of 1000-2000 lux would be required for television coverage</td>
</tr>
</tbody>
</table>

21 EDUCATION

21.1 Assembly Halls
21.1.1 General 200-300-500 3 Special lighting to provide emphasis and to facilitate the use of the platform/ stage is desirable
21.1.2 Platform and stage — — —

21.2 Teaching Spaces
21.2.1 General 200-300-500 1

21.3 Lecture Theatres
21.3.1 General 200-300-500 1
21.3.2 Demonstration benches 300-500-750 1 Localized lighting may be appropriate

21.4 Seminar Rooms 300-500-750 1
21.5 Art Rooms 300-500-750 1
21.6 Needlework Rooms 300-500-750 1
21.7 Laboratories 300-500-750 1

21.8 Libraries 200-300-500 1
21.9 Music Rooms 200-300-500 1
21.10 Sports Halls 200-300-500 1
21.11 Workshops 200-300-500 1

22 TRANSPORT

22.1 Airports
22.1.1 Ticket counters, checking desks, and information desks 300-500-750 2 Localized lighting may be appropriate
22.1.2 Departure lounges, other waiting areas 150-200-300 2
22.1.3 Baggage reclaim 150-200-300 2
22.1.4 Baggage handling 50-100-150 2
22.1.5 Customs and immigration halls 300-500-750 2
22.1.6 Concourse 150-200-300 2

22.2 Railway Stations
22.2.1 Ticket office 300-500-750 2 Localized lighting may be appropriate
22.2.2 Information office 300-500-750 2 Localized lighting over the counter may be appropriate

22.3 Parcels office, left
22.4 Luggage office
22.4.1 General 50-100-150 2
22.4.2 Counter 150-200-300 2
22.4.5 Waiting rooms 150-200-300 2
22.4.6 Concourse 150-200-300 2
22.4.7 Time table 150-200-300 2

22.5.1 Ticket barriers 150-200-300 2 Localized lighting may be appropriate
22.5.2 Platforms (covered) 30-50-100 2 Localized lighting may be appropriate
22.5.10 Platforms (open) 20 — Care should be taken to light and mark the edge of the platform clearly

22.3 Coach Stations
<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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<tbody>
<tr>
<td>22.3.1</td>
<td>Ticket offices</td>
<td>300-300-750</td>
<td>2</td>
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<tr>
<td>22.3.2</td>
<td>Information offices</td>
<td>300-500-750</td>
<td>2</td>
</tr>
<tr>
<td>22.3.3</td>
<td>Left luggage office</td>
<td>30-100-150</td>
<td>3</td>
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<tr>
<td>22.3.3.1</td>
<td>General</td>
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<td>22.3.3.2</td>
<td>Counter</td>
<td>150-200-300</td>
<td>3</td>
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<tr>
<td>22.3.4</td>
<td>Waiting rooms</td>
<td>150-200-300</td>
<td>2</td>
</tr>
<tr>
<td>22.3.5</td>
<td>Corridors</td>
<td>150-200-300</td>
<td>2</td>
</tr>
<tr>
<td>22.3.6</td>
<td>Time offices</td>
<td>150-200-300</td>
<td>2</td>
</tr>
<tr>
<td>22.3.7</td>
<td>Loading areas</td>
<td>100-150-200</td>
<td>3</td>
</tr>
</tbody>
</table>

### GENERAL BUILDING AREAS

| 23.1 | Entrance |
| 23.1.1 | Entrance halls, lobbies, waiting rooms | 150-200-300 | 2 |
| 23.1.2 | Enquiry desks | 300-500-750 | 2 |
| 23.1.3 | Gatehouses | 150-200-300 | 2 |

| 23.2 | Circulation Areas |
| 23.2.1 | Lifts | 50-100-150 | — |
| 23.2.2 | Corridors, passageways, stairs | 50-100-150 | 2 |
| 23.2.3 | Escalators, travelators | 100-150-200 | — |

| 23.3 | Medical and First Aid Centres |
| 23.3.1 | Consulting rooms, treatment rooms | 100-300-500 | 1 |
| 23.3.2 | Rest rooms | 100-150-200 | 1 |
| 23.3.3 | Medical stores | 100-150-200 | 2 |

| 23.4 | Staff Rooms |
| 23.4.1 | Changing, locker and cleansers rooms, cloakrooms, lavatories | 50-100-150 | — |
| 23.4.2 | Rest rooms | 100-150-200 | 1 |

| 23.5 | Staff Restaurants |
| 23.5.1 | Canteens, cafeterias, dining rooms, mess rooms | 150-200-300 | 2 |
| 23.5.2 | Servery, vegetable preparation, washing-up area | 200-300-500 | 2 |
| 23.5.3 | Food preparation and cooking | 300-500-750 | 2 |
| 23.5.4 | Food stores, cellars | 100-150-200 | 2 |

| 23.6 | Communications |
| 23.6.1 | Switchboard rooms | 200-300-500 | 2 |
| 23.6.2 | Telephone apparatus rooms | 100-150-200 | 2 |
| 23.6.3 | Telex room, post room | 300-300-750 | 2 |
| 23.6.4 | Reprographic room | 200-300-500 | 2 |

| 23.7 | Building Services |
| 23.7.1 | Boiler houses |
| 23.7.1.1 | General | 50-100-150 | 3 |
| 23.7.1.2 | Boiler front | 100-150-200 | 3 |
| 23.7.1.3 | Boiler control room | 200-300-500 | 2 |
| 23.7.1.4 | Control rooms | 200-300-500 | 2 |

| 23.7.1.5 | Mechanical plant room | 100-150-200 | 2 |
| 23.7.1.6 | Electrical power supply and distribution rooms | 100-150-200 | 2 |
| 23.7.1.7 | Store rooms | 50-100-150 | 3 |

| 23.8 | Car Parks |
| 23.8.1 | Covered car parks |
| 23.8.1.1 | Floors | 5-20 | — |
| 23.8.1.2 | Ramps and corners | 30 | — |
| 23.8.1.3 | Entrances and exits | 50-100-150 | — |
| 23.8.1.4 | Control booths | 150-300-500 | — |
| 23.8.1.5 | Outdoor car parks | 5-20 | — |
It is important, when lighting stairways, to prevent disability from glare caused by direct sight of bright sources to emphasize the edges of the treads and to avoid confusing shadows. The same precautions should be taken in the lighting of cat-walks and stairways on outdoor industrial plants.

28.5.1.5.2 Entrances

The problems of correctly grading the lighting within a building to allow adequate time for adaptation when passing from one area to another area are particularly acute at building entrances. These are given below:

a. By day, people entering a building will be adapted to the very high levels of brightness usually present outdoors and there is risk of accident if entrance areas, particularly any steps, are poorly lighted. This problem may often be overcome by arranging windows to give adequate natural lighting at the immediate entrance, grading to lower levels further inside the entrance area. Where this cannot be done, supplementary artificial lighting should be installed to raise the level of illumination to an appropriate value.

b. At night it is desirable to light entrance halls and lobbies so that the illumination level reduces towards the exit and so that no bright fittings are in the line of sight of people leaving the building. Any entrance steps to the building should be well-lighted by correctly screened fittings.

28.5.2 Daylight

The primary source of lighting for daylighting is the sun. The light received by the earth from the sun consists of two parts, namely, direct solar illuminance and sky illuminance. For the purposes of daylighting design, direct solar illuminance shall not be considered and only sky illuminance shall be taken as contributing to illumination of the building interiors during the day.

28.5.2.1 The relative amount of sky illuminance depends on the position of the sun defined by its altitude, which in turn, varies with the latitude of the locality, the day of the year and the time of the day.

28.5.2.2 The external available horizontal sky illuminance (diffuse illuminance) values which are exceeded for about 90 percent of the daytime working hours may be taken as outdoor design illuminance values for ensuring adequacy of daylighting design. The outdoor design sky illuminance varies for different climatic regions of the country. The recommended design sky illuminance values are 8000 lux for composite climate, 9000 lux for warm humid climate, and 10500 for hot-dry climate. For integration with the artificial lighting during daytime working hours an increase of 500 lux in the recommended sky design illuminance for daylighting is suggested.

28.5.2.3 The daylight factor is dependent on the sky luminance distribution, which varies with atmospheric conditions. A clear design sky with its non-uniform distribution of luminance is adopted for the purposes of design in this clause.

28.5.2.4 Components of Daylight Factor

Daylight factor is the sum of all the daylight reaching on an indoor reference point from the following sources:

a) the direct sky visible from the point;
b) external surfaces reflecting light directly (see Note 1) to the point; and
c) internal surfaces reflecting and inter-reflecting light to the point.

Notes:
1. External surface reflection may be computed approximately only for points at the centre of the room, and for detailed analysis procedures are complicated and these may be ignored for actual calculations.
2. Each of the three components, when expressed as a ratio or percent of the simultaneous external illuminance on the horizontal plane, defines respectively the sky component (SC), the external reflected component (ERC) and the internal reflected component (IRC) of the daylight factor.
28.5.2.4.1 The daylight factors on the horizontal plane only are usually taken, as the working plane in a room is generally horizontal; however, the factors in vertical planes should also be considered when specifying daylighting values for special cases, such as daylighting on classrooms, blackboards, pictures and paintings hung on walls.

28.5.2.5 Sky Component (SC)

Sky component for a window of any size is computed by the use of the appropriate table of Appendix A.

a) The recommended sky component level should be ensured generally on the working plane at the following positions:
   1) at a distance of 3m to 3.75m from the window along the central line perpendicular to the window;
   2) at the centre of the room if more appropriate; and
   3) at fixed locations, such as school desks, blackboards and office tables.

b) The daylight area of the prescribed sky component should not normally be less than half the total area of the room.

28.5.2.5.1 The values obtainable from the tables are for rectangular, open unglazed windows, with no external obstructions. The values shall be corrected for the presence of window bars, glazing and external obstructions, if any. This assumes the maintenance of a regular cleaning schedule.

28.5.2.5.2 Corrections for window bars

The corrections for window bars shall be made by multiplying the values read from tables in Appendix A by a factor equal to the ratio of the clear opening to the overall opening.

28.5.2.5.3 Correction for glazing

Where windows are glazed, the sky components obtained from Appendix A shall be reduced by 10 to 20 percent, provided the panes are of clear and clean glass. Where glass is of the frosted (ground) type, the sky components read from Appendix A may be reduced by 15 to 30 percent. In case of tinted or reflective glass the reduction is about 50 percent. Higher indicated correction corresponds to larger windows and/or near reference points. In the case of openings and glazings which are not vertical, suitable correction shall be taken into account.

28.5.2.5.4 Correction for external obstructions

There is no separate correction, except that the values from tables in Appendix A shall be read only for the unobstructed portions of the window.

28.5.2.6 External Reflected Component (ERC)

The value of the sky component corresponding to the portion of the window obstructed by the external obstructions may be found by the use of methods described in Appendix B. These values when multiplied by the correction factors, corresponding to the mean elevation of obstruction from the point in question as given in Table 4, can be taken as the external reflected components for that point.

**Table 4: Correction Factor for ERC (Clause 28.5.2.6)**

<table>
<thead>
<tr>
<th>Mean Angle of Elevation</th>
<th>Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>5°</td>
<td>0.086</td>
</tr>
<tr>
<td>15°</td>
<td>0.086</td>
</tr>
<tr>
<td>25°</td>
<td>0.142</td>
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<tr>
<td>35°</td>
<td>0.192</td>
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<td>45°</td>
<td>0.226</td>
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<tr>
<td>55°</td>
<td>0.274</td>
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<tr>
<td>65°</td>
<td>0.304</td>
</tr>
<tr>
<td>75°</td>
<td>0.324</td>
</tr>
<tr>
<td>85°</td>
<td>0.334</td>
</tr>
</tbody>
</table>

28.5.2.6.1 For method of calculating ERC, reference may be made to accepted standard.

28.5.2.7 Internal Reflected Component (IRC)

The component of daylight factor contributed by reflection from the inside surfaces varies directly as the window area and inversely as the total area of internal surfaces, and depends on the reflection factor of the floor, wall and roof surfaces inside and of the ground outside. For rooms white-washed on walls and ceiling and windows of normal sizes, the IRC will have sizeable value even at points far away from the
window. External obstructions, when present, will proportionately reduce IRC. Where accurate values of IRC are desired, the same maybe done in accordance with the good practice.

28.5.2.8 General principles of openings to afford good lighting

28.5.4.2.8.1 Generally, while taller openings give greater penetrations, broader openings give better distribution of light. It is preferable that some area of the sky at an altitude of 20° to 25° should light up the working plane.

28.5.4.2.8.2 Broader openings may also be equally or more efficient, provided their sills are raised by 300 mm to 600 mm above the working plane.

Note:
It is to be noted that while placing window with a high sill level might help natural lighting, this is likely to reduce ventilation at work levels. While designing the opening for ventilation also, a compromise may be made by providing the sill level about 150 mm below the head level of workers.

28.5.2.8.3 For a given penetration, a number of small openings properly positioned along the same, adjacent or opposite walls will give better distribution of illumination than a single large opening. The sky component at any point, due to a number of openings may be easily determined from the corresponding sky component contour charts appropriately superposed. The sum of the individual sky component for each opening at the point gives the overall component due to all the openings. The same charts may also facilitate easy drawing of sky component contours due to multiple openings.

28.5.2.8.4 Unilateral lighting from side openings will, in general, be unsatisfactory if the effective width of the room is more than 2 to 2.5 times the distance from the floor to the top of the opening. In such cases provision of light shelves is always advantageous.

28.5.2.8.5 Openings on two opposite sides will give greater uniformity of internal daylight illumination, especially when the room is 7 m or more across. They also minimize glare by illuminating the wall surrounding each of the opposing openings. Side openings on one side and clear storey openings on the opposite side may be provided where the situation so requires.

28.5.2.8.6 Cross-lighting with openings on adjacent walls tend to increase the diffused lighting within a room.

28.5.2.8.7 Openings in deep reveals tend to minimize glare effects.

28.5.2.8.8 Openings shall be provided with louveres, baffles or other shading devices to exclude, as far as possible, direct sunlight entering the room. Louvers, etc., reduce the effective height of the opening for which due allowance shall be made. Broad and low openings are, in general, much easier to shade against sunlight entry. Direct sunlight, when it enters, increases the inside illuminance very considerably. Glare will result if it falls on walls at low angles, more so than when it falls on floors, especially when the floors are dark coloured or less reflective.

28.5.2.8.9 Light control media, such as translucent glass panes (opal or matt) surfaced by grinding, etching or sandblasting, configurated or corrugated glass, certain types of prismatic glass, tinted glass and glass blasts are often used. They should be provided, either fixed or movable outside or inside, especially in the upper portions of the openings. The lower portions are usually left clear to afford desirable view. The chief purpose of such fixtures is to reflect part of the light on to the roof and thereby increase the diffuse lighting within, light up the farther areas in the room and thereby produce a more uniform illumination throughout. The will also prevent the opening causing serious glare discomfort to the occupants but will provide some glare when illuminated by direct sunlight.

28.5.2.9 Availability of daylight in multi-storeyed block

Proper planning and layout of building can add appreciably to daylighting illumination inside. Certain dispositions of building masses offer much less mutual obstruction to daylight than others and have a significant relevance, especially when intensive site planning is undertaken. The relative availability of daylight in
multi-storeyed blocks of different relative orientations are given in Table 5.

Table 5: Relative availability of daylight on the window plane at ground level in a four storeyed building block (clear design-sky as basis, daylight availability taken as unity on an unobstructed facade, values are for the centre of the blocks)

<table>
<thead>
<tr>
<th>Distance of Separation Between Blocks</th>
<th>Infinitely Long Parallel Blocks</th>
<th>Parallel Blocks Facing Each Other (Length = 2 x Height)</th>
<th>Parallel Blocks Facing Gaps Between Opposite Blocks (Length = 2 x Height)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>0.5 (H_t)</td>
<td>0.15</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>1.0 (H_t)</td>
<td>0.30</td>
<td>0.32</td>
<td>0.38</td>
</tr>
<tr>
<td>1.5 (H_t)</td>
<td>0.40</td>
<td>0.50</td>
<td>0.55</td>
</tr>
<tr>
<td>2.0 (H_t)</td>
<td>0.50</td>
<td>0.60</td>
<td>0.68</td>
</tr>
</tbody>
</table>

28.5.2.10 For specified requirements for daylighting of special occupancies and areas, reference may be made to good practice.

28.5.3 Artificial lighting

28.5.3.1 Artificial lighting may have to be provided:
   a) where the recommended illumination levels have to be obtained by artificial lighting only;
   b) to supplement daylighting when the level of illumination falls below the recommended value; and
   c) where visual task may demand a higher level of illumination.

28.5.3.2 Artificial lighting design for interiors

For general lighting purposes, the recommended practice is to design for a level of illumination on the working plane on the basis of the recommended levels for visual tasks given in Table 4 by a method called 'Lumen method'. In order to make the necessary detailed calculations concerning the type and quantity of lighting equipment necessary, advance information on the surface reflectance of walls, ceilings and floors is required. Similarly, calculations concerning the brightness ratio in the interior call for details of the interior decor and furnishing. Stepwise guidance regarding designing the interior lighting systems for a building using the 'Lumen method' is given in clause 28.5.3.2.1 to 28.5.3.2.4.

28.5.3.2.1 Determination of the illumination level

Recommended value of illumination shall be taken from Table 4, depending upon the type of work to be carried out in the location in question and the visual tasks involved.
28.5.3.2.2 Selection of the light sources and luminaires

The selection of light sources and luminaires depends on the choice of lighting system, namely, general lighting, directional lighting and localized or local lighting.

28.5.3.2.3 Determination of the luminous flux

a) The luminous flux (Φ) reaching the working plane depends upon the following:
   1) lumen output of the lamps;
   2) type of luminaire;
   3) proportion of the room (room index) (kᵣ);
   4) reflectance of internal surfaces of the room;
   5) depreciation in the lumen output of the lamps after burning their rated life; and
   6) depreciation due to dirt collection on luminaires and room surface.

b) Coefficient of utilization or utilization factor
   1) The compilation of tables for the utilization factor requires a considerable amount of calculations, especially if these tables have to cover a wide range of lighting practices. For every luminaire, the exact light distribution has to be measured in the laboratory and their efficiencies have to be calculated and measured exactly. These measurements comprise:
      i) the luminous flux radiated by the luminaires directly to the measuring surface;
      ii) the luminous flux reflected and re-reflected by the ceiling and the walls to the measuring surface; and
      iii) the inter-reflections between the ceiling and wall which result in the measuring surface receiving additional luminous flux.

All these measurements have to be made for different reflection factors of the ceiling and the walls for all necessary room indices. These tables have also to indicate the maintenance factor to be taken for the luminous flux depreciation throughout the life of an installation due to ageing of the lamp and owing to the deposition of dirt on the lamps and luminaires and room surfaces.

2) The values of the reflection factor of the ceiling and of the wall are as follows:

<table>
<thead>
<tr>
<th>Colour</th>
<th>Reflection Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>White and very light colours</td>
<td>0.7</td>
</tr>
<tr>
<td>Light colours</td>
<td>0.5</td>
</tr>
<tr>
<td>Middle tints</td>
<td>0.3</td>
</tr>
<tr>
<td>Dark colours</td>
<td>0.1</td>
</tr>
</tbody>
</table>

For the walls, taking into account the influence of the windows without curtains, shelves and doors with different colours, etc., should be estimated.

c) Calculation for determining the luminous flux

   \[ E_{av} = \mu \Phi / A \]
   or, \[ \Phi = E_{av} A / \mu \] for new condition
   and \[ \Phi = E_{av} A / \mu d \] for working condition

where
   \( \Phi \) = The total luminous flux of the light sources installed in the room in lumens;
   \( E_{av} \) = the average illumination level required on the working plane in lux;
   \( A \) = area of the working plane in \( \text{m}^2 \);
   \( \mu \) = the utilization factor in new conditions; and
   \( d \) = maintenance factor

In practice, it is easier to calculate straightaway the number of lamps or luminaires from:

   \[ N_{lamp} = E_{av} A / \mu d \Phi_{lamp} \]
   or \[ N_{luminaires} = E_{av} A / \mu d \Phi_{luminaires} \]

where
   \( \Phi_{lamp} \) = luminous flux of each lamp in lumens
   \( \Phi_{luminaires} \) = luminous flux of each luminaire in lumens
   \( N_{lamp} \) = total number of lamps
   \( N_{luminaires} \) = total number of luminaires

28.5.3.2.4 Arrangement of the luminaires

This is done to achieve better uniformly distributed illumination. The location of the
luminaires has an important effect on the utilization factor.

a) In general, luminaires are spaced ‘a’ metre apart in either direction, while the distance of the end luminaire from the wall is ‘½ a’ metre. The distance ‘a’ is more or less equal to the mounting height ‘H_m’ between the luminaire and the working plane. The utilization factor tables are calculated for this arrangement of luminaires.

b) For small rooms where the room index \( (k_r) \) is less than 1, the distance ‘a’ should always be less than \( H_m \), since otherwise luminaires cannot be properly located. In most cases of such rooms, four or two luminaires are placed for good general lighting. If, however, in such rooms only one luminaire is installed in the middle, higher utilization factors are obtained, but the uniformity of distribution is poor. For such cases, references should be made to the additional tables for \( k_r = 0.6 \) to 1.25 for luminaires located centrally.

28.5.3.3 Artificial lighting to supplement daylighting

28.5.3.3.1 The need for general supplementary artificial lighting arises due to diminution of daylighting beyond design hours, that is, for solar altitude below 15° or when dark cloudy conditions occur.

28.5.3.3.2 The need may also arise for providing artificial lighting during the day in the innermost parts of the building which cannot be adequately provided with daylighting, or when the outside windows are not of adequate size or when there are unavoidable external obstructions to the incoming daylighting.

28.5.3.3.3 The need for supplementary lighting during the day arises, particularly when the daylighting on the working plane falls below 100 lux and the surrounding luminance drops below 19 cd/m².

28.5.3.3.4 The requirement of supplementary artificial lighting increases with the decrease in daylighting availability. Therefore, conditions near sunset or sunrise or equivalent conditions due to clouds or obstructions, etc, represent the worst conditions when the supplementary lighting is most needed.

28.5.3.3.5 The requirement of supplementary artificial lighting when daylighting availability becomes poor may be determined from Fig. 2 for an assumed ceiling height of 3.0m, depending upon floor area, fenestration percentage and room surface reflectance. Cool daylight fluorescent tubes are recommended with semi-direct luminaires. To ensure a good distribution of illumination, the mounting height should be between 1.5m and 2.0m above the work plane for a separation of 2.0m to 3.0m between the luminaires. Also the number of lamps should preferably be more in the rear half of the room than in the vicinity of windows. The following steps may be followed for using Fig. 3 for determining the number of fluorescent tubes required for supplementary daylighting.

a) Determine fenestration percentage of the floor area, that is,

\[
\text{Window Area} \times \frac{100}{\text{Floor Area}}
\]

b) In Fig. 2, refer to the curve corresponding to the percent fenestration determined above and the set of reflectance of ceiling, walls and floor actually provided.

c) For the referred curve of Fig. 2 read, along the ordinate, the number of 40 W fluorescent tubes required, corresponding to the given floor area on the abscissa.

28.5.3.4 For detailed information on the design aspects and principles of artificial lighting, reference may be made to good practice.

28.5.3.5 For specific requirements for lighting of special occupancies and areas, reference may be made to good practice.

28.5.3.6 Electrical installation aspect for artificial lighting shall be in accordance with this Code.
28.5.4 Energy conservation in lighting

28.5.4.1 A substantial portion of the energy consumed on lighting maybe saved by utilization of daylight and rational design of supplementary artificial lights.

28.5.4.2 Daytime use of artificial lights maybe minimized by proper design of windows for adequate daylight indoors. Daylighting design should be according to Clause 28.5.2.

28.5.4.3 Fenestration expressed as percentage of floor area required for satisfactory visual performance of a few tasks for different separation to height (S/H) ratio of external obstructions such as opposite buildings may be obtained from the design nomograph (Fig.3). The obstructions at a distance of three times their height or more (S/H > 3) from a window facade are not significant and a window facing such an obstruction may be regarded as a case of unobstructed window.

28.5.4.3.1 The nomograph consists of horizontal lines indicating fenestration percentage of floor area and vertical lines indicating the separation to height ratio of external obstructions such as opposite buildings. Any vertical line for separation to height ratio other than already shown in the nomograph (1.0, 2.0 and 3.0) may be drawn by designer, if required. For cases where there is no obstruction, the ordinate corresponding to the value 3.0 may be used. The value of percentage fenestration and separation to height ratio are marked on the left hand ordinate and abscissa respectively. The illumination levels are marked on the right hand ordinate. The values given within the brackets are the illumination levels on the work plane at centre and rear of the room. The wattage of fluorescent tubes required per square metre of the floor area for different illumination levels is shown on each curve.

28.5.4.3.2 The following assumptions have been made in the construction of the monograph.

a) An average interior finish with ceiling white, walls off white and floor grey has been assumed.

b) Ceiling height of 3m and room depths up to 10m and floor area between 30m² and 50m² have been assumed. For floor area beyond 50m² and less than 30m², the values of percent fenestration as well as wattage per m² should be multiplied by a factor of 0.85 and 1.15 respectively.

c) It is assumed that windows are of metallic sashes with louvers of width up to 600 mm or a balcony projection at ceiling level of width up to 2.0 m. For wooden sashes, the window area should be increased by a factor of about 1.1.

d) Luminaires emanating more light in the downward direction than upward direction (such as reflectors with or without diffusing plastics) and mounted at a height of 1.5 m to 2.0 m above the workplane have been considered.
28.5.4.3.3 Method of use

The following steps shall be followed for the use of the nomograph:

a) **Step 1** — Decide the desired illumination level depending upon the task illumination requirement in the proposed room and read the value of watts per square metre on the curve corresponding to the required illumination level.

b) **Step 2** — Fix the vertical line corresponding to the given separation to height ratio of opposite buildings on the abscissa. From the point of interclause of this vertical line and the above curve move along horizontal, and read the value of fenestration percent on the left hand ordinate.

c) **Step 3** — If the floor area is greater than 50 m² and less than 30 m², the value of watts per square metre as well as fenestration percent may be easily determined for adequate daylighting and supplemental artificial lighting for design purposes. However, if the fenestration provided is less than the required value, the wattage of supplementary artificial lights should be increased proportionately to make up for the deficiency of natural illumination.

![Fig. 3: Monograph of daylighting and supplemental lighting design of buildings](image)
28.5.4.4 For good distribution of daylight on the working plane in a room, window height, window width and height of sill should be chosen in accordance with the following recommendations:

a) In office buildings windows of height 1.2m or more in the center of a bay with sill level at 1.0 to 1.2m above floor and in residential buildings windows of height 1.0m to 1.1m with sill height as 0.9m to 0.7m above floor are recommended for good distribution of daylight indoors. Window width can accordingly be adjusted depending upon the required fenestration percentage of the floor area.

b) If the room depth is more than 10m, windows should be provided on opposite sides for bilateral lighting.

c) It is desirable to have a white finish for ceiling and off white (light colour) to white for walls. There is about 7 percent improvement in lighting levels in changing the finish of walls from moderate to white.

28.5.4.5 For good distribution and integration of daylight with artificial lights the following guidelines are recommended:

a) Employ cool daylight fluorescent tubes for supplementary artificial lighting.

b) Distribute luminaries with a separation of 2m to 3m in each bay of 3m to 4m width.

c) Provide more supplementary lights such as twin tube luminaries in work areas where daylight is expected to be poor for example in the rear region of a room having single window and in the central region of a room having windows on opposite walls. In the vicinity of windows only single tube luminaries should be provided.

28.5.4.6 Artificial lighting

Energy conservation in lighting is effected by reducing wastage and using energy effective lamps and luminaires without sacrificing lighting quality. Measures to be followed comprise utilization of daylight, energy effective artificial lighting design by providing required illumination where needed, turning off artificial lights when not needed, maintaining lighter finishes of ceiling, walls and furnishings, and implementing periodic schedule for cleaning of luminaires and group replacement of lamps at suitable intervals. Choice of light sources with higher luminous efficacy and luminaires with appropriate light distribution is the most effective means of energy saving in lighting. However, choice of light sources also depends on the other lighting quality parameters like colour rendering index and colour temperature or appearance. For example, high pressure sodium vapour lamps, which have very high luminous efficacy, are not suitable for commercial interiors because of poor colour rendering index and colour appearance, but are highly desirable in heavy industries. Also the choice of light sources depends on the mounting height in the interiors. For example, fluorescent lamps are not preferred for mounting beyond 7m height, when high pressure gas discharge lamps are preferred because of better optical control due to their compact size.

28.5.4.6.1 Efficient artificial light sources and luminaires

Luminous efficacy of some of the lamps used in lighting of buildings are given in Table 6 along with average life in burning hours, Colour Rendering Index and Colour Temperature.

Following recommendations may be followed in the choice of light sources for different locations:

a) For supplementary artificial lighting of work area in office building care should be taken to use fluorescent lamps, which match with colour temperature of the daylight.

b) For residential buildings fluorescent lamps and/or CFLS of proper CRI and CCT are recommended to match with the colours and interior design of the room.

c) For commercial interiors, depending on the mounting heights and interior design, fluorescent lamps, CFLS and low wattage metal halide lamps are recommended. For highlighting the displays in show windows, hotels, etc., low wattage tubular or dichroic reflector type halogen lamps can be used.

d) For industrial lighting, depending on the mounting height and colour consideration fluorescent lamps, high pressure mercury vapour lamps or high
pressure sodium vapour lamps are recommended.

28.5.4.6.2 For the same lumen output, it is possible to save 75 to 80 percent energy if GLS lamps are replaced with CFL and 65 to 70 percent if replaced with fluorescent lamps. Similar energy effective solutions are to be chosen for every application area. Similarly also throughout its life. Following luminaries are recommended for different locations:

a) For offices semi-direct type of luminaries are recommended so that both the work plane illumination and surround luminance can be effectively enhanced.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Light Source</th>
<th>Efficacy lum/W</th>
<th>Average Life h</th>
<th>CRI</th>
<th>CCT K</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Incandescent lamps</td>
<td>8-18</td>
<td>1 000</td>
<td>100</td>
<td>2 800</td>
</tr>
<tr>
<td>ii)</td>
<td>Tungsten halogen incandescent lamps Mains-voltage types: 60 W-2 000 W Low-voltage types with reflector have lower wattages</td>
<td>10% higher than comparable GLS lamp</td>
<td>2 000</td>
<td>100</td>
<td>3 200</td>
</tr>
<tr>
<td>iii)</td>
<td>Fluorescent lamps (FTL) a) Standard lamps 38 mm (T12) 20 W-65 W 26 mm (T8) 18 W-58 W Cool daylight Warm white</td>
<td>61</td>
<td>5 000</td>
<td>72</td>
<td>6 500</td>
</tr>
<tr>
<td></td>
<td>b) Tri-Phosphor lamps 38 mm (T12) 20 W-65 W 26 mm (T8) 18 W-58 W</td>
<td>67</td>
<td>5 000</td>
<td>57</td>
<td>3 500</td>
</tr>
<tr>
<td>iv)</td>
<td>Compact Fluorescent Lamps (CFL) 5 W-25 W</td>
<td>80-80</td>
<td>8 000</td>
<td>Similar to FTL</td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>High pressure mercury vapour lamps 80 W-400 W</td>
<td>36-60</td>
<td>5 000</td>
<td>45</td>
<td>4 000</td>
</tr>
<tr>
<td>vi)</td>
<td>Blended — Light lamps MLL 100 W-500 W</td>
<td>11-26</td>
<td>5 000</td>
<td>61</td>
<td>3 600</td>
</tr>
<tr>
<td>vii)</td>
<td>High Pressure Sodium Vapour Lamps 50 W-1 000 W</td>
<td>60-130</td>
<td>10 000-15 000</td>
<td>23</td>
<td>2 000</td>
</tr>
<tr>
<td>viii)</td>
<td>Metal halide lamps 35 W-2 000 W</td>
<td>60-83</td>
<td>10 000</td>
<td>68-92</td>
<td>3 000-5 600</td>
</tr>
</tbody>
</table>

Table 6: Luminous Efficacy, Life, CRI and CCT of light sources

with white fluorescent tubes recommended for corridors and staircases, the electrical consumption reduces to 1/4.5 of the energy consumption with incandescent lamps.

28.5.4.6.3 Efficient luminaire also plays an important role for energy conservation in lighting. The choice of a luminaire should be such that it is efficient not only initially but also throughout its life. Following luminaries are recommended for different locations:

b) For corridors and staircases direct type of luminaries with wide spread of light distributions are recommended.

c) In residential buildings, bare fluorescent tubes are recommended. Wherever the incandescent lamps are employed, they should be provided with white enamelled conical reflectors at an inclination of about 45° from vertical.
28.5.4.7 Cleaning schedule for window panes and luminaires

Adequate schedule for cleaning of window panes and luminaries will result in significant advantage of enhanced daylight and lumen output from luminaries. This will tend to reduce the duration over which artificial lights will be used and minimize the wastage of energy. Depending upon the location of the building a minimum of three to six months interval for periodic cleaning of luminaries and window panes is recommended for maximum utilization of daylight and artificial lights.

28.5.4.8 Photocontrols for artificial lights

There is a considerable wastage of electrical energy in lighting of buildings due to carelessness in switching off lights even when sufficient daylight is available indoors. In offices and commercial buildings, occupants may switch on lights in the morning and keep them on throughout the day. When sufficient daylight is available inside, suitable photo controls can be employed to switch off the artificial lights and thus prevent the wastage of energy.

28.5.4.9 Solar Photovoltaic Systems (SPV)

Solar photovoltaic system enables direct conversion of sunlight into electricity and is viable option for lighting purpose in remote non-grid areas. The common SPV lighting systems are:

a) solar lantern;
b) fixed type solar home lighting system; and

c) street lighting system.

28.5.4.9.1 SPV lighting system should preferably be provided with CFL for energy efficiency.

28.5.4.9.2 Invertors used in buildings for supplying electricity during the power cut period should be charged through NW system.

28.5.4.9.3 Regular maintenance of SPV system is necessary for its satisfactory functioning.

28.6 ELECTRICAL POWER AND LIGHTING SYSTEMS

28.6.1 General (Mandatory).

This clause covers lighting system controls, the maximum lighting power for interior and exterior applications and electrical energy consumption.

Dwelling units within multifamily buildings shall comply with Clause R404.1. All other dwelling units shall comply with this Code, or with Clauses 28.6.2.4 and 28.6.3. Sleeping units shall comply with Clause 28.6.2.4, or 28.6.3. Lighting installed in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with the lighting requirements of this Code.

28.6.2 Lighting controls (Mandatory).

Lighting systems shall be provided with controls that comply with one of the following.

1. Lighting controls as specified in Clauses 28.6.2.1 through 28.6.2.6.

2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Clauses 28.6.2.1, 28.6.2.4 and 28.6.2.5. The LLC luminaire shall be independently capable of:

2.1. Monitoring occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.

2.2. Monitoring ambient light, both electric light and daylight, and brighten or dim artificial light to maintain desired light level.

2.3. For each control strategy, configuration and reconfiguration of performance parameters including; bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configurations.

Exceptions: Lighting controls are not required for the following:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Interior exit stairways, interior exit ramps and exit passageways.

3. Emergency egress lighting that is normally off.

**28.6.2.1 Occupant sensor controls.**
Occupant sensor controls shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges/breakrooms.
5. Enclosed offices.
6. Open plan office areas.
7. Restrooms.
8. Storage rooms.
9. Locker rooms.
10. Other spaces 28 m\(^2\) (300 square feet) or less that are enclosed by floor-to-ceiling height partitions.
11. Warehouse storage areas.

**28.6.2.1.1 Occupant sensor control function.**
Occupant sensor controls in warehouses shall comply with Clause 28.6.2.1.2. Occupant sensor controls in open plan office areas shall comply with Clause 28.6.2.1.3. Occupant sensor controls for all other spaces specified in Clause 28.6.2.1 shall comply with the following:

1. They shall automatically turn off lights within 20 minutes after all occupants have left the space.
2. They shall be manual on or controlled to automatically turn on the lighting to not more than 50-percent power.

**Exception:** Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

3. They shall incorporate a manual control to allow occupants to turn off lights.

**28.6.2.1.2 Occupant sensor control function in warehouses.**
In warehouses, the lighting in aisleways and open areas shall be controlled with occupant sensors that automatically reduce lighting power by not less than 50 percent when the areas are unoccupied. The occupant sensors shall control lighting in each aisleway independently and shall not control lighting beyond the aisleway being controlled by the sensor.

**28.6.2.1.3 Occupant sensor control function in open plan office areas.**
Occupant sensor controls in open plan office spaces less than 28 m\(^2\) (300 square feet) in area shall comply with Clause 28.6.2.1.1. Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 55 m\(^2\) (600 square feet) within the open plan office space.
2. The controls shall automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.
3. The controls shall be configured so that general lighting power in each control zone is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of all occupants leaving that control zone. Control functions that switch control zone lights completely off when the zone is vacant meet this requirement.
4. The controls shall be configured such that any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.

28.6.2.2 Time-switch controls.

Each area of the building that is not provided with occupant sensor controls complying with Clause 28.6.2.1.1 shall be provided with time-switch controls complying with Clause 28.6.2.2.1.

Exception: Where a manual control provides light reduction in accordance with Clause 28.6.2.2.2, time-switch controls shall not be required for the following:

1. Spaces where patient care is directly provided.
2. Spaces where an automatic shutoff would endanger occupant safety or security.
3. Lighting intended for continuous operation.
4. Shop and laboratory classrooms.

28.6.2.2.1 Time-switch control function.

Each space provided with time-switch controls shall be provided with a manual control for light reduction in accordance with Clause 28.6.2.2.2. Time-switch controls shall include an override switching device that complies with the following:

1. Have a minimum 7-day clock.
2. Be capable of being set for seven different day types per week.
3. Incorporate an automatic holiday “shutoff” feature, which turns off all controlled lighting loads for not fewer than 24 hours and then resumes normally scheduled operations.
4. Have program backup capabilities, which prevent the loss of program and time settings for not fewer than 10 hours, if power is interrupted.

5. Include an override switch that complies with the following:

5.1. The override switch shall be a manual control.
5.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.
5.3. Any individual override switch shall control the lighting for an area not larger than $465 \text{ m}^2$ (5,000 square feet).

Exceptions:

1. Within mall concourses, auditoriums, sales areas, manufacturing facilities and sports arenas:
   1.1. The time limit shall be permitted to be greater than 2 hours, provided that the switch is a captive key device.
   1.2. The area controlled by the override switch shall not be limited to $465 \text{ m}^2$ (5,000 square feet) provided that such area is less than $1860 \text{ m}^2$ (20,000 square feet).
2. Where provided with manual control, the following areas are not required to have light reduction control:
   2.1. Spaces that have only one luminaire with a rated power of less than 100 watts.
   2.2. Spaces that use less than $6.5 \text{ W/m}^2$ (0.6 watts per square foot).
   2.3. Corridors, lobbies, electrical rooms and or mechanical rooms.

28.6.2.2.2 Light-reduction controls.

Spaces required to have light-reduction controls shall have a manual control that allows the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by
not less than 50 percent. Lighting reduction shall be achieved by one of the following or another approved method:

1. Controlling all lamps or luminaires.

2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps.

3. Switching the middle lamp luminaires independently of the outer lamps.

4. Switching each luminaire or each lamp.

**Exception:** Light reduction controls are not required in **daylight zones** with **daylight responsive controls** complying with Clause 28.6.2.3.

### 28.6.2.3 Daylight-responsive controls.

Daylight-responsive controls complying with Clause 28.6.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelit zones complying with Clause 28.6.2.3.2 General lighting does not include lighting that is required to have specific application control in accordance with Clause 28.6.2.4.

2. Spaces with a total of more than 150 watts of general lighting within toplit zones complying with Clause 28.6.2.3.3.

**Exceptions:** Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.

2. Lighting that is required to have specific application control in accordance with Clause 28.6.2.4.

3. Sidelit zones on the first floor above grade in Group A-2 and Group M occupancies.

4. New buildings where the total connected lighting power calculated in accordance with Clause 28.6.3.1 is not greater than the adjusted interior lighting power allowance \( (LPA_{adj}) \) calculated in accordance with Equation 4-9:

\[
LPA_{adj} = \left( \frac{LPA_{norm} \times (1.0 - 0.4 \times \frac{UDZFA}{TBFA})}{1.0} \right)
\]

(Equation 4-9)

where:

- \( LPA_{adj} \) = Adjusted building interior lighting power allowance in watts.
- \( LPA_{norm} \) = Normal building lighting power allowance in watts calculated in accordance with Clause 28.6.3.2 and reduced in accordance with this Code.
- \( UDZFA \) = Uncontrolled daylight zone floor area is the sum of all sidelit and toplit zones, calculated in accordance with Clauses 28.6.2.3.2 and 28.6.2.3.3, that do not have daylight responsive controls.
- \( TBFA \) = Total building floor area is the sum of all floor areas included in the lighting power allowance calculation in Clause 28.6.3.2.

### 28.6.2.3.1 Daylight-responsive control function.

Where required, daylight-responsive controls shall be provided within each space for control of lights in that space and shall comply with all of the following:

1. Lights in toplit zones in accordance with Clause 28.6.2.3.3 shall be controlled independently of lights in sidelit zones in accordance with Clause 28.6.2.3.2.

2. Daylight responsive controls within each space shall be configured so that they
can be calibrated from within that space by authorized personnel.

3. Calibration mechanisms shall be in a location with ready access.

4. Where located in offices, classrooms, laboratories and library reading rooms, daylight responsive controls shall dim lights continuously from full light output to 15 percent of full light output or lower.

5. Daylight responsive controls shall be configured to completely shut off all controlled lights.

6. Lights in sidelit zones in accordance with Clause 28.6.2.3.2 facing different cardinal orientations [within 45 degrees (0.79 rad) of due north, east, south, west] shall be controlled independently of each other.

   Exception: Up to 150 watts of lighting in each space is permitted to be controlled together with lighting in a daylight zone facing a different cardinal orientation.

28.6.2.3.2 Sidelit zone.
The sidelit zone is the floor area adjacent to vertical fenestration that complies with all of the following:

1. Where the fenestration is located in a wall, the sidelit zone shall extend laterally to the nearest full-height wall, or up to 1.0 times the height from the floor to the top of the fenestration, and longitudinally from the edge of the fenestration to the nearest full-height wall, or up to 610 mm (2 feet), whichever is less, as indicated in Figure 28.6.2.3.2.

2. The area of the fenestration is not less than $2.23 \text{ m}^2$ (24 square feet).

3. The distance from the fenestration to any building or geological formation that would block access to daylight is greater than the height from the bottom of the fenestration to the top of the building or geological formation.

4. The visible transmittance of the fenestration is not less than 0.20.

28.6.2.3.3 Toplit zone.
The toplit zone is the floor area underneath a roof fenestration assembly that complies with all of the following:

1. The toplit zone shall extend laterally and longitudinally beyond the edge of the roof fenestration assembly to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.7 times the ceiling.
2. Where the fenestration is located in a rooftop monitor, the toplit zone shall extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the fenestration, whichever is less, as indicated in Figures 28.6.2.3.3(2) and 28.6.2.3.3(3).

3. Direct sunlight is not blocked from hitting the roof fenestration assembly at the peak solar angle on the summer solstice by buildings or geological formations.

4. The product of the visible transmittance of the roof fenestration assembly and the area of the rough opening of the roof fenestration assembly divided by the area of the toplit zone is not less than 0.008.
28.7 DISTRIBUTION OF SUPPLY AND CABLING

28.7.1 General

In the planning and design of an electrical wiring installation, due consideration shall be made of all the prevailing conditions. It is recommended that advice of a competent electrical engineer be sought at the initial stage itself with a view to providing an installation, that will prove adequate for its intended purpose be reliable and safe and efficient.

A certain redundancy in the electrical system is necessary and has to be built in from the initial design stage itself. The extent of redundancy will depend on the type of load, its criticality, normal hours of use, quality of power supply in that area, co-ordination with the standby power supply, capacity to meet the starting current requirements of large motors, etc.

28.7.2 System of Supply

28.7.2.1 All electrical apparatus shall be suitable for the voltage and frequency of supply.

28.7.2.2 In case of connected load of 100 kVA and above, the relative advantage of high voltage three-phase supply should be considered. Though the use of high voltage supply entails the provisions of space for the capital cost of providing suitable transformer substation at the consumer's premises, the following advantages are gained:

a) advantage in tariff;

b) more effective earth fault protection for heavy current circuits;

c) elimination of interference with supplies to other consumers permitting the use of large size motors, welding plant, etc., and

d) better control of voltage regulation and more constant supply voltage.

Note: Additional safety precautions required to be observed in HV installations shall also be kept in view.
In many cases there may be no choice available to the consumer, as most of the licenses have formulated their policy of correlating the supply voltage with the connected load or the contract demand. Generally the supply is at 400/230 volts, 11 kV (or 22 kV) for loads up to 5 MVA and 33 kV or 66 kV for consumers of more than 5 MVA.

28.7.2.3 In very large industrial buildings where heavy electric demands occur at scattered locations, the economics of electrical distribution at high voltage from the main substation to other subsidiary transformer substations or to certain items of plant, such as large motors and furnaces, should be considered. The relative economy attainable by use of medium or high voltage distribution and high voltage plant is a matter for expert judgement and individual assessment in the light of experience by a professionally qualified electrical engineer.

28.7.3 Substation equipment and accessories

Substations require an approval by the Electrical Inspectorate. Such approval is mandatory before energizing the substation. It is desirable to get the approval for the general layout, schematic layout, protection plan etc., before the start of the work from the Inspectorate. All substation equipment and accessories and materials, etc, shall conform to relevant Indian Standards wherever they exist, otherwise the consumer (or his consultant) has to specify the standards to which the equipment to be supplied conforms and that shall be approved by the authority. Manufacturers of equipment have to furnish certificate of conformity as well as type test certificates for acceptance tests and installation related tests for earthing, earth continuity, load tests and tests for performance of protective gear.

28.7.3.1 High voltage switchgear

28.7.3.1.1 The selection of the type of high voltage switchgear for any installation inter alia depends upon the following:

a) voltage of the supply system

b) the prospective short-circuit current at the point of supply;

c) the size and layout of electrical installation;

d) the accommodation available; and

e) the nature of industry.

Making and breaking capacity of switchgear shall be commensurate with short-circuit potentialities of the supply system and the supply authority shall be consulted on this subject.

28.7.3.1.2 Guidelines on various types of switchgear equipment and their choice for a particular application shall be in accordance with good practice.

28.7.3.1.3 In extensive installations of switchgear (having more than four incoming supply cables or having more than 12 circuit breakers), banks of switchgears shall be segregated from each other by means of fire-resisting barriers having 2h fire resistance rating in order to prevent spreading of the risk of damage by fire or explosion arising from switch failure. Where a bus-bar clause switch is installed, it shall also be segregated from adjoining banks in the same way. Except main LT panel, it would be preferable to locate the sub panels/distribution boards near load centre. Further, it should be ensured that these panels are easily approachable. The preferable location of panels shall be near the exit ways.

28.7.3.1.4 It should be possible to isolate any clause from the rest of the switchboards such that work might be undertaken on this clause without the necessity of making the switchboard dead. Isolating switches used for the interconnection of clauses or for the purpose of isolating circuit-breakers of other apparatus, shall also be segregated within its compartment so that no live part is accessible when work in a neighbouring clause is in progress.

28.7.3.1.5 In the case of duplicate or ring main supply, switchgears with interlocking arrangement shall be provided with interlocking arrangement shall be provided to prevent simultaneous switching of two different supply sources. Electrical and/or mechanical interlocks may preferably be provided.
28.7.3.2 Cables

28.7.3.2.1 The smallest size of the cable that shall be used, will depend upon the method of laying cable, permissible maximum temperature it shall withstand, voltage drop over the length of the cable, the prospective short-circuit current to which the cable may be subjected, the characteristics of the overload protection gear installed, load cycle and thermal resistivity of the soil.

28.7.3.2.2 The advice of the cable manufacturer with regard to installation, jointing and sealing shall be followed.

28.7.3.2.3 The HV cables shall either be laid on the cable rack/built-up concrete trenches/tunnel/basement or directly buried in the ground depending upon the specific requirement. It is preferable to use four core cable in place of three and half core to minimize heating of neutral core due to harmonic content in the supply system and also avoidance of overload failures. All cables shall be installed in accordance with good practice.

28.7.3.2.4 Colour identification of cores of non-flexible cables

<table>
<thead>
<tr>
<th>Function</th>
<th>Colour Identification of core of rubber of pvc insulated non-flexible cable, or of sleeve or disc to be applied to conductor or cable Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective or earthing</td>
<td>Green and yellow or Green with yellow stripes 1)</td>
</tr>
<tr>
<td>Neutral of a.c. single or three-phase circuit</td>
<td>Red</td>
</tr>
<tr>
<td>Phase R of 3-phase a.c. circuit</td>
<td>Yellow</td>
</tr>
<tr>
<td>Phase Y of 3-phase a.c. circuit</td>
<td>Blue</td>
</tr>
<tr>
<td>Phase B of 3-phase a.c. circuit</td>
<td>Red</td>
</tr>
<tr>
<td>Positive of d.c. 2-wire circuit</td>
<td>Black</td>
</tr>
<tr>
<td>Outer (positive or negative) of d.c. 2-wire circuit derived from 3-wire system</td>
<td>Red</td>
</tr>
<tr>
<td>Positive of 3-wire system positive of 3-wire d.c. circuit</td>
<td>Red</td>
</tr>
<tr>
<td>Middle wire of 3-wire d.c. circuit</td>
<td>Black</td>
</tr>
<tr>
<td>Negative of 3-wire d.c. circuit</td>
<td>Blue</td>
</tr>
<tr>
<td>Functional Earth-Telecommunication</td>
<td>Cream</td>
</tr>
</tbody>
</table>

1) Bare conductors are also used for earthing and earth continuity conductors. But it is preferable to use insulated conductors with green insulation with yellow strips

28.7.3.2.5 Colour, identification of cores of flexible cables and flexible cords.

<table>
<thead>
<tr>
<th>Number of Cores</th>
<th>Function of Core</th>
<th>Colour(s) of Core</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

926
28.7.3.3 High voltage busbar trunking/ducting

High voltage busbar trunking system is a type-tested switchgear and control gear assembly in the form of an enclosed system. HV bus system is used for transporting power between HV Generators, transformers and the in feed main switchgear of the main HV switchgear.

Generally three types of bus ducts namely non-segregated, segregated and isolated phase bus duct shall be used. The non-segregated bus ducts consists of three phase busbars running in a common enclosure made of steel or aluminum. The enclosure shall provide safety for the operational personnel and reduces chances of faults. The enclosures shall be effectively grounded.

Segregated phase bus duct are similar to non-segregated phase duct except that metal or insolation barriers are provided between phase conductors to reduce chances of phase to phase faults. However, it is preferable to use metal barriers.

In the case of isolated bus ducts, each phase conductor shall be housed in separate non-magnetic enclosures. The bus duct shall be made of clauses which are assembled together at site to make complete assembly. The enclosure shall be of either round or square shape and welded construction. The enclosures of all phases in general to be supported on a common steel structure. Provision of fire protection shall be provided in all openings in accordance with Part 3 ‘Use and Occupancy’.

Fire separation in openings shall be provided using materials having 2h fire resistance rating.

28.7.3.4 MV/LV busbar trunking/rising mains

Where heavy loads are to be carried, busbar systems are preferred. The busbars are available for continuous run from point to point or with tap offs at standard intervals and have to be chosen as per specific requirement. MV/LV busbar trunking shall be a type-tested switchgear and control gear assembly in the form of an enclosed system. There are two types of MV/LV bus duct system for power distribution system:

a) conventional type
b) compact and sandwich type.

Conventional type bus duct is used for large power handling between transformer and switchger or between switchgear and large power loads, such as compressor drive motor etc. This type is generally used in plant rooms, riser shafts, substations etc.

Compact type is available either air insulated or sandwich type for use within areas of the building which are put to other higher (aesthetic) level of use. They could be used in false ceiling spaces or even in corridors and shafts for distribution without any false ceiling as they provide an aesthetically acceptable finish to merge with other building elements such as beams, ducts or pipes in functional buildings.

The class of protection shall be specific depending on the requirement at the place of installation. Protection class (IPxx) will automatically identify the ventilation, protection from weather, water, dust, etc.
In modern building technology, high demands are made of the power distribution system and its individual components:

a) Long life and good service quality,
b) Safe protection in the event of fire,
c) Low fire load,
d) Low space requirement, and
e) Minimum effort involved in carrying out retrofits.

The high load density in modern large buildings and high rise buildings demands compact and safe solution for the supply of power. The use of busbar trunking system is ideal for such applications.

Busbar trunking can be installed in vertical risers ducts or horizontally in passages for transmission and distribution of power. Busbar trunking systems allow electrical installations to be planned in a simple and clear fashion. In the building complexes, additional safety demands with respect to fire barriers and fire load and use of bus bar trunking meets this requirement.

Busbar trunking system reduces the combustible material near the area with high energy in comparison with other distribution systems such as cables and makes the building safe from the aspect of vulnerability to fire of electrical origin. In addition, unlike cable systems the reliability of a bus trunking system is very high. These systems also require very little periodic maintenance.

Choice of busbar trunking for distribution in buildings can be made on the basis of:

a) Reduced fire load (drastically reduced in comparison to the cable system).

b) Reduced maintenance over its entire lifetime.

c) Longer service lifetime in comparison with a cable distribution.

d) Enhanced reliability due to rigid bolted joints and terminations and extremely low possibility of insulation failure.

28.7.3.5 Transformers

28.7.3.5.1 General design objective while selecting the transformer(s) for a substation would be to provide at least two or more transformers, so that a certain amount of redundancy is built in, even if a standby system is provided. The total installed transformation capacity would be marginally higher than the anticipated maximum demand. With growing emphasis on energy conservation, the system design is made for both extremes of loading. During the periods of lowest load in the system, it would be desirable to operate only one transformer and switch in additional transformers as the load variation takes place in a day. The minimum size of a transformer would quite often depend on the minimum load that is anticipated over a period of about 4 h in a day. Total transformer capacity is generally selected on the basis of present load, possible future load, operation and maintenance cost and other system conditions and selection of the maximum size (capacity) of the transformer is guided by short-circuit making and breaking capacity of the switchgear used in the medium voltage distribution system. Maximum size limitation is important from the aspect of feed to a downstream fault.

For feeding final single phase domestic type of loads or general office loads it is advisable to even use transformers of capacity much lower than what the switchgear can handle, so that lower fault MVA is available in such areas and use of hand held equipment fed through flexible cords is safe.

For reasons of reliability and redundancy it is normal practice to provide at least two transformers for any important installation. Interlinking by tie lines is an alternative to enhance reliability/redundancy is areas where there are a number of substations in close vicinity, such as a campus with three or four multi-storeyed blocks each with a substation.

Ring main type of distribution is preferred for complexes having a number of substations.

28.7.3.5.2 Where two or more transformers are to be installed in a substation to supply a medium voltage distribution system, the distribution system shall be divided into separate clauses each of which shall be normally fed from one transformer only unless the medium voltage switchgear has the requisite short-circuit capacity. Provision may, however, be made to interconnect separate clauses, through a bus coupler in the event of failure or disconnection of
one transformer. See Clause 28.4.2 for details of location and requirements of substation.

The transformers, that may at any time operate in parallel, shall be so selected as to share the load in proportion to their respective load ratings. While the general practice is to avoid operation of transformers in parallel for feeding final distribution in buildings, it is possible to use transformers with slightly different impedance or voltage taps to operate in parallel, but with appropriate protection. Installations designed for parallel operation of transformers shall have protection for avoiding circulating current between transformers, avoid overload of anyone transformer due to reactance mismatch and the system shall be so arranged as to trip the secondary breaker in case the primary breaker of that transformer trips.

28.7.3.5.6 Switchgear

28.7.3.5.6.1 Switchgear (and its protective device) shall have breaking capacity not less than the anticipated fault level in the system at that point. System fault level at a point in distribution system is predominantly dependent on the transformer size and its reactance. Parallel operation of transformers naturally increases the fault level.

28.7.3.5.6.2 Isolation and controlling circuit breaker shall be interlocked so that the isolator cannot be operated unless the corresponding breaker is in open condition. The choice between alternative types of equipment may be influenced by the following considerations:

a) In certain installations supplied with electric power from remote transformer substations, it may be necessary to protect main circuits with circuit-breakers operated by earth fault, in order to ensure effective earth fault protection.

b) Where large electric motors, furnaces or other heavy electrical equipment is installed, the main circuits shall be protected from short-circuits by switch disconnector fuse or circuit breakers. For motor protection, the combination of contactor overload device and fuse or circuit breakers shall be Type-2 coordinated in accordance with accepted standards. Wherever necessary, back up protection and earth fault protection shall be provided to the main circuit.

c) Where mean of isolating main circuits is separately required, switch disconnector fuse or switch disconnector may form part of main switchboards.

28.7.3.5.6.3 It shall be mandatory to provide power factor improvement capacitor at the substation bus. Suitable capacitor may be selected in consultation with the capacitor as well as switchgear manufacture depending upon the nature of electrical load anticipated on the system. Necessary switchgear/feeder circuit breaker shall be provided for controlling of capacitor bank.

Power factor of individual motor may be improved by connecting individual capacitor banks in parallel. For higher range of motors, which are running continuously without much variations in load, individual power factor correction at load end is advisable.

Note: Care should be taken in deciding the kVA rating of the capacitor in relation to the magnetising kVA of the motor. Over rating of the capacitor may cause injury to the motor and capacitor bank. The motor still rotating after disconnection from the supply, may act as generator by self-excitation and produce a voltage higher than supply voltage. If the motor is again switched on before the speed has fallen to about 80 percent of the normal running speed, the high voltage will be superimposed on the supply circuits and will damage both the motor and capacitor.

As a general rule, the kVA rating of the capacitor should not exceed the no-load magnetizing kVA of the motor.

Generally it would be necessary to provide an automatic control for switching in capacitors matching the load power factor and the bus voltage. Such a scheme would be necessary as capacitors permanently switched in the circuit may cause over voltage at times of light load.

28.7.3.5.6.4 Sufficient additional space shall be allowed in substations and switchrooms to allow operation and maintenance and proper means shall be provided for isolating the equipment to allow access for servicing, testing and maintenance. Sufficient additional space shall
be allowed for temporary location and installation of standard servicing and testing equipment. Space should also be allowed to provide for anticipated future extensions.

28.7.3.6.5 Electrical installations in a room or cubicule or in an area surrounded by wall fence, access to which is controlled by lock and key shall be considered accessible to authorized persons only.

A wall or fence less than 1.8m in height shall not be considered as preventing access unless it has other features that provide a degree of isolation equivalent to a 1.8m fence.

28.7.3.6.6 Harmonics on the supply systems are becoming a greater problem due to the increasing use of electronic equipments, computer, fluorescent, mercury vapour and sodium vapour lighting, controlled rectifier and inverters for variable speed drives, power electronics and other non-linear loads. Harmonics may lead to almost as much current in the neutral as in the phases. This current is almost entirely third harmonic. Phase rectification devices may be considered for the limits of harmonic voltage distortion may be considered at the planning stage in such cases.

With the wide spread use of thyristor and rectifier based loads there is necessity of providing a full size neutral; but this requirement is limited to the 3-phase 4-wire distribution generally in the 400/230 V system. As a result it is not desirable to use half-size neutral conductor, as possibility of neutral conductor overload due to harmonics is likely.

28.7.3.6 Reception and distribution of main supply

28.7.3.6.1 Control at point of commencement of supply

28.7.3.6.1.1 There shall be a circuit-breaker or miniature circuit-breakers or a load break switch fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no switch or fuse unit in the earthed neutral conductor. The neutral shall also be distinctly marked. In this connection, Rules, as amended up to date shall also be referred.

28.7.3.6.1.2 The main switch shall be easily accessible and situated as near as practicable to the termination of service line.

28.7.3.6.1.3 On the main switch, where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor or a multi-wire system or a conductor which is to be connected thereto, an indication of a permanent nature shall be provided to identify the earthed neutral conductor. In this connection, Electricity Company of Ghana Rules, shall be referred as amended up-to-date.

28.7.3.6.1.4 Energy meters

Energy meters shall be installed in residential buildings at such a place which is readily accessible to the owner of the building and the Authority. These should be installed at a height where it is convenient to note the meter reading, it should preferably not be installed below one metre from the ground. The energy meters should either be provided with a protecting covering, enclosing it completely except the glass window through which the readings are noted or should be mounted inside a completely enclosed panel provided with hinged or sliding doors with arrangement for locking.

In multi-storeyed buildings meters shall be installed with tapping point for meters of the rising main (bus trunking) on individual floors.

28.7.3.6.2 Main switches and switchboard

28.7.3.6.2.1 All main switches shall be either of metal-clad enclosed pattern or of any insulated enclosed pattern which shall be fixed at close proximity to the point of entry of supply. Every switch shall have an environmental protection level rating (IP), so that its operation is satisfactory in the environment of the installation.

Note: Woodwork shall not be used for the construction or mounting of switches and switch boards installed in a building.

28.7.3.6.2.2 Location

a) The location of the main board should be such that it is easily accessible for fireman and other personnel to quickly disconnect the supply in case of emergencies. If the room is locked for security, means of emergency access,
by schemes such as break glass cupboard, shall be incorporated.

b) Main switch board shall be installed in rooms or cupboards so as to safeguard against operation by unauthorized personnel.

c) Switchboards shall be placed only in dry situations and in ventilated rooms and they shall not be placed in the vicinity of storage batteries or exposed to chemical fumes.

d) In damp situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switchboard shall be totally enclosed and shall have adequate degree of protection. In some cases flameproof enclose may be necessitated by particular circumstances.

e) Switchboards shall not be erected above gas stoves or sinks, or within 2.5m or any washing unit in the washing rooms or laundries, or in bathrooms, lavatories or toilets, or kitchens.

f) In case of switchboards unavoidably fixed in places likely to be exposed to weather, to drip, or to abnormal moist temperature, the outer casing shall be weatherproof and shall be provided with glands or bushings or adopted to receive screwed conduit, according to the manner in which the cables are run.

g) Adequate illumination shall be provided for all working spaces about the switchboards when installed indoors.

28.7.3.6.2.3 Metal-clad switchgear shall preferably be mounted on any of the following types of boards:

a) Hinged-type metal boards – These shall consist of a box made of sheet metal not less than 2 mm thick and shall be provided with a hinged cover to enable the board to swing open for examination of the wiring at the back.

The joints shall be welded. There shall be a clear distance of not less than 2/5 cm between the teak wood board and the cover, the distance being increased for larger boards in order that on closing of the cover, the insulation of the cables is not subjected to damage and there should be no excessive twisting or bending in any case. The board shall be securely fixed to the wall by means of rag bolts, plugs, or wooden plugs and shall be provided with a locking arrangement and an earthing stud. All wires passing through the metal board shall be protected by a rubber or wooden bush at the entry hole. The earth stud should commensurate with the size of earth lead/leads. Alternatively, metal boards may be made of suitable size angle iron of minimum size 35mm x 35mm x 6mm or channel iron of minimum size 35 mm x 25mm x 6mm frames work tagged to specification on front with a 3mm thick mild steel plate and on back with 1.5mm thick mid steel sheet. No apparatus shall project beyond any edge of panel. No fuse body shall be mounted within 2.5 cm of any edge of the panel.

Note: Such type of boards are particularly suitable for small switchboard for mounting metal-clad switchgear connected to supply at low voltages.

b) Fixed-type metal boards – These shall consist of an angle or channel iron frame fixed on the wall or on floor and supported on the wall at the top, if necessary. There shall be a clear distance of 1m in front of the switchboards. If there are any attachments of bare connections at the back of the switchboards ECG rules shall apply. The connections between the switchgear mounting and the outgoing cable up to the wall shall be enclosed in a protection pipe.

Note: Such type of boards are particularly suitable for large switchboards for mounting large number of switchgears or high capacity metal-clad switchgear or both.

c) Protected-type switchboard – A protected switchboard is one where all
of the conductors are protected by metal or other enclosures. They may consist of a metal cubicle panel, or an iron frame upon which is mounted metal-clad switchgear. They usually consist of a main switch, busbars and circuit breakers or fuses controlling outgoing circuits.

d) **Open-type switchboard** – An open type switchboard is one, which has exposed current carrying parts on the front of the switchboard. This type of switchboard is rarely used now-a-days but where this exists, a hand rail or barrier has to be provided to prevent unintentional or accidental contact with exposed live parts. They must be located in a special switch room or enclosure and only a competent person may have access to these switchboards.

**Note** – These boards may be existing in old installations. It is recommended that they be phased out. With the continuously increasing fault power feed due to increases in generation and strengthening of distribution systems, these open boards are a source of accidents.

### 28.7.3.6.2.4 Recessing of boards

Where so specified, the switchboards shall be recessed in the wall. Ample room shall be provided at the back for connection and at the front between the switchgear mountings.

### 28.7.3.6.2.5 Marking of apparatus

a) Where a board is connected to voltage higher than 250 V, all the apparatus mounted on it shall be marked on the following colours to indicate the different poles or phases to which the apparatus or its different terminals may have been connected.

<table>
<thead>
<tr>
<th><strong>Alternating Current</strong></th>
<th><strong>Direct Current</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-phases – red, yellow, blue</td>
<td>Three-wire system – 2 outer wire, positive red and negative blue</td>
</tr>
<tr>
<td>1 Neutral – black</td>
<td>1 Neutral - black</td>
</tr>
</tbody>
</table>

Where four-wire three phase wiring is done, the neutral shall be in one colour and the other three wires in another colour as mentioned above or shall be suitably tagged or sleeved for fool proof identification.

b) Where a board has more than one switch, each such switch shall be marked to indicate which clause of the installation it controls. The main switch shall be marked as such and where there is more than one main switch in the building, each such switch shall be marked to indicate which clause of the installation it controls.

All markings shall be clear and permanent.

#### 28.7.3.6.2.6 Drawings

Before proceeding with the actual construction, a proper drawing showing the detailed dimensions and design including the disposition of the mountings of the boards, which shall be symmetrically and neatly arranged for arriving at the overall dimensions, shall be prepared along the building drawing. Such drawings will show the mandatory clearance spaces if any, and clear height below the soffit of the beam to satisfy regulations and safety considerations, so that other designers or installers do not get into such areas or spaces for their equipment.

#### 28.7.3.6.2.7

Where a board has more than one switch, each such switch shall be marked to indicate which clause of the installation it controls. The main switch shall be marked as such and where there is more than one main switch in the building, each such switch shall be marked to indicate which clause of the installation it controls.

All markings shall be clear and permanent.

#### 28.7.3.6.2.8

Busbar chambers, which feed two or more circuits, must be controlled by a main disconnnector (TP & N), or Isolating links or TPN MCB to enable them to be disconnected from the supply.

### 28.7.3.6.3 Distribution boards

A distribution board comprises of one or more protective devices against over current and ensuring the distribution of electrical energy to
the circuits. Distribution board shall provide plenty of wiring space, to allow working as well as to allow keeping the extra length of connecting cables, likely to be required for maintenance.

28.7.3.6.3.1 Main distribution board shall be provided with a circuit breaker on each pole of each circuit, or a switch with a fuse on the phase or live conductor and a link on the neutral or earthed conductor of each circuit. The switches shall always be linked.

All incomers should be provided with surge protection devices.

28.7.3.6.4 Branch distribution boards

28.7.3.6.4.1 Branch distribution boards shall be provided, along with earth leakage protective device (ELCB) (incoming), with a fuse or a miniature circuit breaker or both of adequate rating/setting chosen on the live conductor of each sub-circuit and the earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes. At least one spare circuit of the same capacity shall be provided one each branch distribution board. Further, the individual branching circuits (outgoing) shall be protected against over-current with miniature circuit breaker of adequate over-current with miniature circuit breaker of adequate rating. In residential/industrial lighting installations, the various circuits shall be separated and each circuit shall be individually protected so that in the event of fault, only the particular circuit gets connected.

28.7.3.6.4.2 Circuits shall be separated for installation at higher level such as those in the ceiling and at higher levels, above 1 cm. on the walls and for installations at lower level such as sockets for portable or stationery plug in equipments. For devices consuming high power and which are to be supplied through supply cord and plug, separate wiring shall be done. For plug-in equipment provisions shall be made for providing ELCB protection in the distribution board.

28.7.3.6.4.3 It is preferable to have additional circuit for kitchen and bathrooms. Such sub-circuit shall not have more than a total of ten points of light, fans and 6A socket outlets. Where the load of such circuit is provided, the number of fans in the circuit shall not exceed ten. Power sub-circuit shall be designed according to the load but in no case shall there be more than two 16A outlets on each sub-circuit.

28.7.3.6.4.4 The circuits for lighting of common area shall be separate. For large halls 3-wire control with individual control and master control installed near the entrance shall be provided for effective conservation of energy.

28.7.3.6.4.5 Where daylight would be available, particularly in large halls, lighting in the area near the windows, likely to receive daylight shall have separate controls for lights, so that they can be switched off selectively when daylight is adequate, while keeping the lights in the areas remote from the windows on.

28.7.3.6.4.6 Circuits for socket outlets may be kept separate circuits feeding fans and lights. Normally, fans and lights may be wired on a common circuit. In large spaces circuits for fans and lights may also be segregated. Lights may have group control in large halls and industrial areas. While providing group control consideration may be given for the nature of use of the area lit by a group. Consideration has to be given for the daylight utilization, while grouping, so that a group feeding areas receiving daylight can be selectively switched off during daylight period.

28.7.3.6.4.7 The load on any low voltage sub-circuit shall not exceed 3000W. In case of a new installation, all circuits and sub-circuits shall be designed with an initial load of about 2500 W, so as to allow a provision of 20 percent increase in load due to any future modification. Power sub-circuits shall be designed according to the load, where the circuit is meant for a specific equipment. Good practice is to limit a circuit to a maximum of four sockets, where it is expected that there will be diversity due to use of very few sockets in large spaces (example sockets for use of vacuum cleaner). General practice is to limit it to two sockets in a circuit, in both residential and non-residential buildings and to provide a single socket on a circuit for a known heavy load appliance such as air conditioner, cooking range etc.
28.7.3.6.4.8 In wiring installations at special places like construction sites, stadium, shipyards, open yards in industrial plants, etc. where a large number of high wattage lamp may be required, there shall be no restriction of load on any circuit but conductors used in such circuits shall be of adequate size for the load and proper circuit protection shall be provided.

28.7.3.6.5 Location of distribution boards

a) the distribution boards shall be located as near as possible to the centre of the load they are intended to control;

b) These shall be fixed on suitable stanchion or wall and shall be accessible for replacement/reset of protective devices, and shall not be more than 1.8m from floor level.

c) These shall be of either metal-clad type, or air insulated type. But, if exposed to weather or damp situations, these shall be of the weatherproof type and, if installed where exposed to explosive dust, vapour or gas, these shall be of flameproof type in accordance with accepted standards. In corrosive atmospheres, these shall be treated with anti-corrosive preservative or covered with suitable plastic compound.

d) Where two and/or more distribution boards feeding low voltage circuits are fed from a supply of medium voltage, the metal case shall be marked ‘Danger 415 V’ and identified with proper phase marking and danger marks.

e) Each shall be provided with a circuit list giving diagram of each circuit which it controls and the current rating of the circuit and size of fuse element.

f) In wiring branch distribution board, total load of consuming devices shall be divided as far as possible evenly between the number of ways in the board leaving space circuits for future extension.

28.7.3.6.6 Protection of circuits

a) Appropriate protection shall be provided at switchboards, distribution boards and at all levels of panels for all circuits and sub-circuits against short circuits, over-current and other parameters as required. The protective device shall be capable of interrupting maximum prospective short circuit current that may occur, without danger. The ratings and settings of fuses and the protective devices shall be co-ordinated so as to afford selectivity in operation and in accordance with accepted standards.

b) Where circuit-breakers are used for protection of a main circuit and of the sub-circuits derived therefrom, discrimination in operation may be achieved by adjusting the protective devices of the sub-main circuit-breakers to operate at lower current settings and shorter time-tag than the main circuit-breaker.

c) Where HRC type fuses are used for back-up protection of circuit-breakers, or where HRC fuses are used for protection of main circuits, and circuit-breakers for the protection of sub-circuits derived there from, in the event of short-circuits protection exceeding the short-circuits capacity of the circuit-breakers, the HRC fuses shall operate earlier than the circuit-breakers; but for smaller overloads within the short-circuit capacity of the circuit-breakers, the circuit-breakers shall operate earlier than the BRIC fuse blows.

d) If re-wireable type fuses are used to protect sub-circuits derived from a main circuit protected by HRC type fuses, the main circuit fuse shall normally blow in the event of a short-circuit or earth fault occurring on sub-circuit, although discrimination may be achieved in respect of overload currents. The use of re-wireable fuses is restricted to the circuits with short-circuit level of 4 kA; for higher level either cartridge or HRC fuses shall be used. However, use of requireable fuse is not desirable, even for lower fault level areas. MCB’s provide a better and dependable protection, as their current setting is not temperable.
e) A fuse carrier shall not be fined with a fuse element larger than that for which the carrier is designed.

f) The current rating of a fuse shall not exceed the current rating of the smallest cable in the circuit protected by the fuse.

g) Every fuse shall have its own case or cover for the protection of the circuit and an indelible indication of its appropriate current rating in an adjacent conspicuous position.

28.7.4 Voltage and frequency of supply

It should be ensured that all equipment connected to the system including any appliances to be used on them are suitable for the voltage and frequency of supply of the system. The nominal values of low and medium voltage systems in Ghana are 240V and 415 V ac., respectively, and the frequency 50 Hz.

Notes

1. The design of wiring system and the sizes of the cables should be decided taking into account two factors;

   a) Voltage Drop – This should be kept as low as economy permits to ensure proper functioning of all electrical appliances and equipment including motors; and
   
   b) First cost against operating losses.

2. In view of the latest development at the international level, nominal system voltages have been aligned with IEC recommendation and accordingly the nominal ac system voltage shall be changed from 240/415 V to 230/400 V ac., with a tolerance of ± 10 percent.

28.7.5 Rating of cables and equipments

28.7.5.1 The current carrying capacity of different types of cables shall be chosen in accordance with good practice.

28.7.5.2 The current ratings of switches for domestic and similar purposes are 6A and 16A.

28.7.5.3 The current ratings of isolators and normal duty switches and composite units of switches and fuses shall be selected from one of the following values:

16, 25, 32, 63, 100, 160, 200, 320, 400, 500, 630, 800, 1,000 and 1,250 A.

28.7.5.4 The ratings of re-wireable and HRC fuses shall be in accordance with good practice.

28.7.5.5 The current ratings of miniature circuit-breakers shall be chosen from the values given below:

6, 8, 10, 13, 16, 20, 25, 32, 40, 50, 63, 80, 100 and 125 A

28.7.5.6 The current ratings of moulded case circuit-breakers shall be chosen from the values given below.

100, 125, 160, 200, 250, 315, 400, 630, 800, 1,000, 1,250 and 1,600 A.

28.7.5.7 The current ratings of air circuit-breakers shall be chosen from the values given below:

630, 800, 1,000, 1,250, 1,600, 2,000, 2,500, 3,200 and 4,000 A.

9.2.5.5.8 The current ratings of the distribution fuse board shall be selected from one of the following values:

6, 16, 25, 32, 63 and 100 A.

28.7.6 Installation circuits

<table>
<thead>
<tr>
<th>Type of Circuit</th>
<th>Wire Size</th>
<th>Number of Circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td></td>
<td>2 or more</td>
</tr>
<tr>
<td>Socket-outlets</td>
<td></td>
<td>Any number</td>
</tr>
<tr>
<td>10 A</td>
<td>1.0 mm²</td>
<td>Areas such as</td>
</tr>
<tr>
<td></td>
<td>2.0 2.5mm²</td>
<td>kitchens and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>laundries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 x double</td>
</tr>
<tr>
<td></td>
<td></td>
<td>socket-outlets per</td>
</tr>
<tr>
<td></td>
<td></td>
<td>circuit.</td>
</tr>
<tr>
<td>Water heater</td>
<td></td>
<td>Other areas</td>
</tr>
<tr>
<td>3 kW</td>
<td>2.5mm²</td>
<td>up to 12</td>
</tr>
<tr>
<td></td>
<td>1.5mm²</td>
<td>double</td>
</tr>
<tr>
<td></td>
<td>2.5mm²</td>
<td>socket-outlets</td>
</tr>
<tr>
<td></td>
<td>6.0mm²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0mm²</td>
<td></td>
</tr>
</tbody>
</table>
936

3-6 kW
Free standing electric range
Separate oven and/or cook top
Permanently connected appliances including dishwashers, heaters, etc.
Submain to garage or outbuilding
Mains cable

<table>
<thead>
<tr>
<th>Circuits</th>
<th>Minimum Wire Size</th>
<th>Wire Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-way lighting</td>
<td>2 + E cable 1.5mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>2-way lighting control (straps between the 2 switches)</td>
<td>3-wire cable 1.5mm²</td>
<td>Red-White-Blue</td>
</tr>
<tr>
<td>Storage water heaters up to 3 kW</td>
<td>2 + E cable 1.5mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Storage water heaters between 3 kW and 6 kW</td>
<td>2 + E cable 2.5mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Socket-outlets and permanent connection units</td>
<td>2 + E cable 2.5mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Sub mains to garages or out buildings</td>
<td>2 + E cable 2.5mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Cooking hobs</td>
<td>2 + E cable 4 mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Separate ovens</td>
<td>2 + E cable 4mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Electric range</td>
<td>2 + E cable 6mm²</td>
<td>Red-Black-Green or Green/Yellow</td>
</tr>
<tr>
<td>Mains</td>
<td>2 wire cable 16 mm²</td>
<td>Red-Black</td>
</tr>
</tbody>
</table>

For the purpose of this Code cables above 1 mm² must have stranded conductors. All cables when installed, must be adequately protected against mechanical damage. This can be carried out by either having additional protection, such as being enclosed in PVC conduit or metal pipes, or placing the cables in a suitable location that requires no additional protection. The cables for wiring circuits in electrical installation must have the appropriate wire size matching the requirement of the loads and the following table gives the recommendations for different types of loads.
Switch or isolator controlling a water heater or geyser should not be located within 1m from the location of a shower or bath tub, to avoid a person in wet condition reaching the switch or isolator. It is preferable to provide the control switch outside the bathroom near the entrance and provide an indication at the water heater. A socket or a connector block with suitable protection against water spray should be provided to connect the water heater. The above considerations apply to switches for outdoor lights and other appliances, with the object of avoidance of operation of a switch when a person is wet. Socket in kitchen, bathroom, toilet, garage etc. should not be provided within a height of 1m from the ground level. Similar care has to be taken for installations involving foundations, swimming pools etc. Light fittings in such areas should be fed at low voltage, preferably through an isolating transformer with a proper earth leakage protection.

### 28.7.6.2 Requirements for physical protection of underground cables

<table>
<thead>
<tr>
<th>Protective Element</th>
<th>Specifications</th>
</tr>
</thead>
</table>
| Bricks             | a) 100mm minimum width  
b) 25mm thick  
c) Sand cushioning 100mm and sand cover 100 mm |

The trench shall be backfilled to cover the cable initially by 200mm of fill; and then a plastic market strip over the full length of cable in the trench. Fill the trench shall be laid before filling the full trench. The marker signs where any cable enters or leaves a building shall be put. This will identify that there is a cable located underground near the building. If the cables rise above ground to enter a building or other structure, a mechanical protection such as a GI pipe or PVC pipe for the cable from the trench depth to a height of 2.0m above ground shall be provided.

### 28.7.7 Lighting and levels of illumination

#### 28.7.7.1 General

Lighting installation shall take into consideration the many factors on which the quality and quantity of artificial lighting depends. The modern concept is to provide illumination with the help of a large number of light sources not of higher illumination level. Also much higher levels of illumination are called for, than in the past, often necessitating the use of fluorescent lighting suitably supplemented with incandescent fittings, where required.
28.7.7.2 Future demand

However, if for financial reasons, it is not possible to provide a lighting installation to give the recommended illumination levels, the wiring installation at least should so designed that at a later date, it will permit the provision for additional lighting fittings or conversion from incandescent to fluorescent lighting fittings to bring the installation to the required standard. It is essential that adequate provisions should be made for all the electrical services which may be required immediately and during the intended useful life of the building.

28.7.7.3 Principles of lighting

When considering the function of artificial lighting, attention should be given to the following principle characteristics before designing an installation.

a) Illumination and its uniformity;
b) Special distribution of light. This includes a reference to the composition of diffused and directional light, direction of incidence, the distribution of luminances and the degree of glare; and
c) Colour of the light and colour rendition.

28.7.7.4 The variety of purposes which have to be kept in mind while planning the lighting installation could be broadly grouped as:

a) industrial buildings and processes;
b) offices, schools and public buildings;
c) surgeries and hospitals; and
d) hostels, restaurants, shops and residential buildings.

9.2.5.7.4.1 It is important that appropriate levels of illumination for these and the types and positions of fittings determined to suit the task and the disposition of the working planes.

28.7.7.5 For specific requirements for lighting of special occupancies, reference shall be made to good practice.

28.7.7.6 Energy conservation

Energy conservation may be achieved by using the following:

a) Energy efficient lamps, chokes, ballast, etc. for lighting equipment
b) Efficient switching systems such as remote sensors, infrared switches, master switches, remote switches, etc. for switching ON and OFF of lighting circuits.
c) Properly made/connected joints contacts to avoid loose joints leading to loss of power.

28.7.8 In conditions where the system voltage exceeds 650V, as is the case in industrial locations, for details of design and construction wiring installation, reference may be made to good practice.

28.7.9 Guidelines for electrical layout in residential buildings

For guidelines for electrical layout in residential buildings, reference may be made to good practice.

A typical distribution scheme in a residential building with separate circuits for lights and fans and for power appliances is given in Fig. 1.

28.7.10 For detailed information regarding the installation of different electrical equipment, reference may be made to good practice.
FIG. 1 WIRING DIAGRAM FOR A TYPICAL DISTRIBUTION BOARD SCHEME IN A RESIDENTIAL BUILDING FLAT
28.8 WIRING
(Reference to the Ghana Wiring Code GS 1119)

28.9 FITTING AND ACCESSORIES

28.9.1 Ceiling roses and similar attachments

28.9.1.1 A ceiling rose or any other similar attachment shall not be used on a circuit the voltage of which normally exceeds 250 V.

28.9.1.2 Normally, only one flexible cord shall be attached to a ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.

28.9.1.3 A ceiling rose shall not embody fuse terminal as an integral part of it.

28.9.2 Socket-outlets and plugs

Each 16 A socket-outlet provided in buildings for the use of domestic appliances such as air conditioner, water cooler, etc. shall be provided with its own individual fuse, with suitable discrimination with back-up fuse or miniature circuit-breaker provided in the distribution/sub-distribution board. The socket-outlet shall not necessarily embody the fuse as an integral part of it.

28.9.2.1 Each socket-outlet shall also be controlled by a switch which shall preferably be located immediately adjacent thereto or combined therewith.

28.9.2.2 The switch controlling the socket-outlet shall be on the live side of the line.

28.9.2.3 Ordinary socket-outlet may be fixed at any convenient place at a height above 20 cm from the floor level and shall be away from danger of mechanical injury.

Note: In situations where a socket-outlet is accessible to children, it is necessary to install an interlocked plug and socket or alternatively a socket-outlet which automatically gets screened by the withdrawal of plug. In industrial premises socket-outlet of rating 20 A and above shall preferably be provided with interlocked type switch.

28.9.2.4 In an earthed system of supply, a socket-outlet with plug shall be of three-pin type with the third terminal connected to the earth. When such socket-outlets with plugs are connected to any current consuming device of metal or any non-insulating material or both, conductors connecting such current-consuming devices shall be of flexible cord with an earthing core and the earthing core shall be secured by connecting between the earth terminal of the plug and the body of current-consuming devices.

In industrial premises three-phase and neutral socket-outlets shall be provided with an earth terminal either of pin type or scrapping type in addition to the main pins required for the purpose.

28.9.2.5 In wiring installations, metal clad switch, socket-outlet and plugs shall be used for power wiring.

Note: A recommended schedule of socket-outlets in a residential building is given below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of 5A Socket-Outlets</th>
<th>Number of 5A Socket-Outlets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed room</td>
<td>2 to 3</td>
<td>1</td>
</tr>
<tr>
<td>Living room</td>
<td>2 to 3</td>
<td>2</td>
</tr>
<tr>
<td>Kitchen</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Dining room</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Garage</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>For refrigerator</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>For air conditioner</td>
<td>-</td>
<td>(one for each)</td>
</tr>
<tr>
<td>Verandah</td>
<td>1 per 10 m²</td>
<td>1</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

28.9.3 Lighting fittings

28.9.3.1 A switch shall be provided for control of every lighting fitting or a group of lighting fittings. Where control at more than one point is necessary as many two way or intermediate switches may be provided as there are control points.

28.9.3.2 In industrial premises lighting fittings shall be supported by suitable pipe/conduits, brackets fabricated from structural steel, steel chains or similar materials depending upon the
type and weight of the fittings. Where a lighting fitting is supported by one or more flexible cords, the maximum weight to which the twin flexible cords may be subjected shall be as follows:

<table>
<thead>
<tr>
<th>Nominal Cross-Clause Area of Twin Cord (mm²)</th>
<th>Maximum Permissible Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>0.75</td>
<td>3</td>
</tr>
<tr>
<td>1.0</td>
<td>5</td>
</tr>
<tr>
<td>1.5</td>
<td>5.3</td>
</tr>
<tr>
<td>2.5</td>
<td>8.8</td>
</tr>
<tr>
<td>4</td>
<td>140</td>
</tr>
</tbody>
</table>

28.9.3.3 No flammable shade shall form a part of lighting fittings unless such shade is well protected against all risks of fire. Celluloid shade or lighting fittings shall not be used under any circumstances.

28.9.3.4 General and safety requirements for electrical lighting fittings shall conform to accepted standards.

28.9.4 Fitting – wire

The use of fittings-wire shall be restricted to the internal wiring of the lighting fittings. Where fittings-wire is used for wiring fittings, the sub-circuit loads shall terminate in a ceiling rose or box with connectors from which they shall be carried into the fittings.

28.9.5 Lamp holders

Lamp holders for use on brackets and the like shall be in accordance with accepted standards and all those for use with flexible pendants shall be provided with shade carriers. All lamp holders shall be provided with shade carriers. Where centre-contact Edison screw lamp holders are used, the outer or screw contacts shall be connected to the ‘middle wire’, the neutral, the earthed conductor of the circuit.

28.9.6 Outdoor lamps

External and road lamps shall have weatherproof fittings of approved design so as to effectively prevent the ingress of moisture and dust. Flexible cord and cord grip lamp holders shall not be used where exposed to weather. In verandahs and similar exposed situations where pendants are used, these shall be of fixed nod type.

28.9.7 Lamps

All lamps unless otherwise required and suitably protected, shall be hung at a height of not less than 2.5m above the floor level. All electric lamps and accessories shall conform to accepted standards.

a) Portable lamps shall be wired with flexible cord. Hand lamps shall be equipped with a handle of moulded composition or other material approved for the purpose. Hand lamps shall be equipped with a substantial guard attached to the lamp holder or handle. Metallic guards shall be earthed suitably.

b) A bushing or the equivalent shall be provided where flexible cord enters the base or stem of portable lamp. The bushing shall be of insulating material unless a jacketed type of cord is used.

c) All wiring shall be free from short-circuits and shall be tested for these defects prior to being connected to the circuit.

d) Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least 125 mm between live parts and the mounting plane of the fixture.

28.9.8 Fans, regulators and clamps

28.9.8.1 Ceiling fans

Ceiling fans including their suspension shall conform to accepted standards and to the following requirements.

a) Control of a ceiling fan shall be through its own regulator as well as a switch in series.

b) All ceiling fans shall be wired with normal wiring to ceiling roses or to special connector boxes to which fan rod wires shall be connected and suspended from hooks and suspension rods. There shall
be no joint in the suspension rod, but if joints are unavoidable then such joints shall be screwed to special couplers of 5 cm minimum length and both ends of the pipes shall touch together within the couplers, and shall in addition be secured by means of split pins; alternatively, the two pipes may be welded. The suspension rod shall be of adequate strength to withstand the dead and impact forces imposed on it. Suspension rods should preferably be procured along with the fan.

c) Fan clamps shall be of suitable design according to the nature of construction of ceiling on which these clamps are to be fitted. In all cases fan clamps shall be fabricated from new metal of suitable sizes and they shall be as close fitting as possible. Fan clamps for wooden beams, shall be of suitable flat iron fixed on two sides of the beam and according to the size and clause of the beam one or two mild steel bolts passing through the beam shall hold both flat irons together. Fan clamps for steel joist shall be fabricated from flat iron to fit rigidly to the bottom flange of the beam. Care shall be taken during fabrication that the metal does not crack while hammer to shape. Other fan clamps shall be made to suit the position, but in all cases care shall be taken to see that they are rigid and safe.

d) Canopies on top and bottom of suspension rods shall effectively conceal suspensions and connections to fan motors, respectively.

e) The lead-in-wire shall be of nominal cross-clauseal area not less than 1.5mm² copper and shall be protected from abrasion.

f) Unless otherwise specified, the clearance between the lowest most point of the ceiling fan and the floor shall be not less than 2.4m. The minimum clearance between the ceiling and the plane of the blades shall be not less than 300mm.

A typical arrangement of a fan clamp is given in Fig.2.

Note: All fan clamps shall be so fabricated that fans revolve steadily.

28.9.8.2 Exhaust fans

For fixing of an exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame which shall be fixed by means of rag-bolts embedded in the wall. The hole shall be neatly plastered with cement and brought to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.

28.9.9 Attachment of fittings and accessories

28.9.9.1 In wiring other than conduit wiring, all ceiling roses, brackets, pendants and accessories attached to walls or ceilings shall be mounted on substantial teak wood blocks twice varnished after all fixing holes are made in them. Blocks shall not be less than 4 cm deep. Brass screws shall only be use for attaching fittings and accessories to their base blocks.

28.9.9.2 Where teak or hardwood boards are used for mounting switches, regulators, etc. these boards shall be well varnished with pure shellac on all four sides (both inside and outside), irrespective of being painted to match the surroundings. The size of such boards shall depend on the number of accessories that could conveniently and neatly be arranged. Where there is danger of attack by white ants, the boards shall be treated with suitable anti-termite compound and painted on both sides.
NOTES
1 RCC slab steel reinforcement not shown.
2 Fan clamp shall be placed in position such that its projecting arms in the line of length of beam.

FIG. 2 TYPICAL DESIGN OF FAN CLAMPS
28.9.10 Interchangeability

Similar part of all switches, lamp holders, distribution fuse-boards, ceiling roses, brackets, pendants, fans and all other fittings shall be so chosen that they are of the same type and interchangeable in each installation.

28.9.11 Equipment

Electrical equipment which form integral part of wiring intended for switching or control or protection of wiring installations shall conform to the relevant Indian Standards wherever they exist.

28.9.12 Fannage

28.9.12.1 Where ceiling fans are provided, the bay sizes of a building, which control fan point locations, play an important part.

28.9.12.2 Fans normally cover an area of 9 m² to 10m² and therefore in general purpose office buildings, for every part of a bay to be served by the ceiling fans, it is necessary that the bays shall be so designed that full number of fans could be suitably located for the bay, otherwise it will result in ill-ventilated pockets. In general, fans in long halls may be spaced at 3m in both the directions. If building modules do not lend themselves for proper positioning of the required number of ceiling fans, such as air circulators or bracket fans would have to be employed for the areas uncovered by the ceiling fans. For this, suitable electrical outlets shall be provided although result will be disproportionate to cost on account of fans.

28.9.12.3 Proper air circulation could be achieved either by larger number of smaller fans or smaller number of larger fans. The economics of the system as a whole should be a guiding factor in choosing the number and type of fans and their locations.

28.9.12.4 Exhaust fans are necessary for spaces, such as community toilets, kitchens and canteens to provide the required number of air changes. Since the exhaust fans are located generally on the outer walls of a room appropriate openings in such walls shall be provided for in the planning stage.

Note: Exhaust fan requirement is based on the recommended air changes. Reference may also be made to Part 3 ‘Use and Occupancy’. Exhaust fan requirement comes for catering to smoke extraction also. Basement areas depend on the system of fresh air fans and exhaust fans.

28.9.12.5 Positioning of fans and light fittings shall be chosen to make these effective without causing shadows and stroboscopic effect on the working planes.

28.10 EARTHING

28.10.1 General

Earthing shall generally be carried out in accordance with the relevant regulations of the ECG.

The main earthing system of an electrical installation must consist of:

a) An earth electrode;

b) A main earthing wire;

c) An earth bar (located on the main switchboard) for the connection of the main earthing wire, protective earthing wires and/or bonding wires within the installation; and

d) A removable link, which effectively disconnects the neutral bar from the earth bar.

Note: The requirements of (c) and (d) above must be carried out by the licensed electrician as part of the switchboard installation.

The main earthing wire termination must be readily accessible at the earth electrode.

The main earthing wire connection must:

a) Be mechanically and electrically sound;

b) Be protected against damage, corrosion, and vibration;

c) Not place any strain on the various part of the connection;

d) Not damage the wire or fittings; and

e) Be secured at the earth electrode.

Use a permanent fitting (like a screwed-down plastic label or copper label, or one that can be threaded onto the cable) at the connection point that is clearly marked with the words: “EARTHING LED – DO NOT DISCONNECT” or “EARTHING CONDUCTOR – DO NOT DISCONNECT”.

28.10.1.1 All medium voltage equipment shall be earthed by two separate and distinct connections with earth. The contact area of
earth conductor/plate shall be determined using guidelines specified in GS IS 3043 (Refer to Electrical Regulation 2012, LI 2008).

The system of 400/230 V (HV/LV), 4-wire, 3 phase system are normal in Ghana operated with the neutral solidly earthed at source. The neutral will carry a current more than the national out-of-balance current and as such neutral conductor shall be of the **same size** as the phase conductor.

In the case of high and extra high voltages, the neutral points shall be earthed by not less than two separate and distinct connections with earth, each having its own electrode at the generating station or substation and may be earthed at any other point provided no interference is caused by such earthing. The neutral may be earthed through suitable impedance not more than 10 ohms.

28.10.1.2 As far as possible, all earth connection shall be visible for inspection.

28.10.1.3 Earth system shall be so devised that the testing of individual earth electrode is possible. It is recommended that the value of any earth system resistance shall be such as to conform with the degree of shock protection desired.

28.10.1.4 It is recommended that a drawing showing the main earth connection and earth electrodes be prepared for each installation.

28.10.1.5 No addition to the current-carrying system, either temporary or permanent, shall be made which will increase the maximum available earth fault current or its duration until it has been ascertained that the existing arrangement of earth electrodes, earth busbar, etc. are capable of carrying the new value of earth fault current which may be obtained by this addition.

28.10.1.6 No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and the live conductors, shall be inserted on any supply system. This, however, does not include the case of a switch for use in controlling a generator or a transformer or a link for test purposes.

28.10.1.7 All materials, fittings, etc. used in earthing shall conform to Indian Standard specifications, wherever these exists.

28.10.1.8 Earthing associated with current-carrying conductor is normally essential for the security of the system and is generally known as system earthing, while earthing of non-current carrying metal work and conductor is essential for the safety of human life, of animals and of property and it is generally known as equipment earthing.

28.10.2 Earth electrodes

The system of 400/230 V (HV/LV), 4-wire, 3 phase system are normal in Ghana operated with the neutral solidly earthed at source. The neutral will carry a current more than the national out-of-balance current and as such neutral conductor shall be of the same size as the phase conductor. Details of typical pipe and pila earth electrodes are given in Fig.3 and Fig.4.

Although electrode material does not affect initial earth resistance, care should be taken to select a material which is resistant to corrosion in the type of soil in which it is used. Under ordinary conditions of soil, use of copper, iron or mild steel electrodes is recommended. In the case where soil condition leads to excessive corrosion of the electrode, and the connections, it is recommended to use either copper electrode or copper clad electrode or zinc coastal galvanised iron electrode. The electrode shall be kept free from paint, enamel and grease. It is recommended to use similar material for earth electrodes and earth conductors or otherwise precautions should be taken to avoid corrosion.

28.10.3 As far as possible, all earth connections shall be in concrete inspection chambers visible for inspection and shall be carefully made; if they are poorly made or inadequate for the purpose for which they are intended, loss of life and property or serious personal injury may result.

To obtain low overall resistance the current density should be as low as possible in the medium adjacent to the electrodes; which should be so designed as to cause the current density to decrease rapidly with distance from the electrode. This requirement is met by
making the dimensions in one direction large compared with those in the other two, thus a pipe, rod or strip has a much lower resistance than a plate of equal surface area. The resistance is not, however, inversely proportional to the surface area of the electrode.

28.10.4 Equipment and portions of installations which shall be earthed

28.10.4.1 Equipment to be earthed

Except for equipment provided with double insulation, all the non-current carrying metal parts of electrical installations are to be earthed properly. All metal conduits, trunking, cable sheaths, switchgear, distribution fuseboards, lighting fittings and all other parts made of metal shall be blended together and connected by means of two separate and distinct conductors to an efficient earth electrode.

28.10.4.2 Structural metal work

Earthing of the metallic parts shall not be effected through any structural metal work which houses the installation. Where metallic parts of the installation are not required to be earthed and are liable to become alive should insulations of conductors become defective, such metallic parts shall be separated by durable non-conducting material from any structural work.

28.10.5 Neutral earthing

To comply with ECG rules no fuses or circuit breakers other than a linked circuit breaker shall inserted in an earthed neutral conductor, a linked switch or linked circuit breaker shall be arranged to break or the neutral either with or after breaking all the related phase conductors and shall positively make (or close) the neutral before making (or closing) the phases.

If this neutral point of the supply is connected permanently to earth, then the above rule applies throughout the insulation including 2-wire final circuits. This means that no fuses may be inserted in the neutral or common return wire. And the neutral should consist of a bolted solid link, or part of a linked switch, which completely disconnects the whole system from the supply. This linked switch must be arranged so that the neutral makes before, and break after the phases.
Fig. 3 Typical Arrangement of Pipe Earthing

All dimensions are in millimetres.
28.10.6 System of earthing

Equipment and portions of installations shall be deemed to be earthed only if earthed in accordance with the direct earthing system, the multiple earthed neutral system or the earth leakage circuit-breaker system. In all cases, the relevant provisions of ECG rules shall be complied with.

The earthing of electrical installations for non-industrial and industrial buildings shall be done in accordance with good practice.
28.10.7 Classification of earthing system

The earthing systems are classified as follows:

a) **TN System** – A system which has one or more points of the source of energy directly earth, and the exposed and extraneous conductive parts of the installation are connected by means of protective conductors to the earth points of the source, that is, currents to flow from the installation to the earth points of the source.

b) **TT System** – A system which has one or more points of the source of energy directly earth, and the exposed and extraneous conductive part of the installation are connected to a local earth electrodes or electrodes electrically independent of the source earth.

c) **IT System** – A system which has sourced either unearthed or earthed through a high impedance and the exposed conducive parts of the installations are connected to electrically independent earth electrodes.

generally conform to the relevant GSA Specification wherever applicable. If there is no relevant GSA Specification for any item, these shall be approved by the appropriate authority.

28.11.5 Completion drawings

On completion of the electric work, a wiring diagram shall be prepared and submitted to the engineer-in-charge or the owner. All wiring diagrams shall indicate clearly, the main switch board, the runs of various mains and sub-mains and the position of all points and their controls. All circuits shall be clearly indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit in which they are electrically connected. Also the location and number of earth points and the run of each load should be clearly shown in the as-built drawings.

28.11 Inspection of the installation

28.11.1 General

On completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of this Code and that of ECG have been complied with. This, among other things, shall include checking whether all equipments, fittings, accessories, wires/cables, used in the installation are of adequate rating and quality to meet the requirement of the load. General workmanship of the electrical wiring with regard to the layout and finish shall be examined for neatness that would facilitate easy identification of circuits of the system, adequacy of clearances, soundness, contact pressure and contact area. A compete check shall also be made of all the protective devices, with respect to their ratings, range of settings and co-ordination between the various protective devices.

28.11.2 Item to be inspected

28.11.2.1 Substation installation

In substation installation, it shall be checked whether:

1) The installation has been carried out in accordance with the approved drawings;
2) Phase-to-phase and phase to earth clearances are provided as required;
3) All equipments are efficiently earthed and properly connected to the required number of earth electrodes;
4) The required ground clearance to live-terminals is provided;
5) Suitable fencing is provided with gate with lockable arrangements;
6) The required number of caution boards fire-fighting equipments, operating rods, rubber mats, etc. are kept in the substation;
7) In the case of indoor substation sufficient ventilation and draining arrangements are made;
8) All cable trenches are provided with non-inflammable covers;
9) Free accessibility is provided for all equipments for normal operation;
10) All name plates are fixed and the equipments are fully painted;
11) All construction materials and temporary connections are removed;
12) Oil-level, busbar tightness, transformer tap position, etc. are in order;
13) Earth pipe troughs and cover slabs are provided for earth electrodes/earth pits and the neutral and LA earth pits are marked for easy identification;
14) Earth electrodes are of GI pipes or CI pipes or copper plates. For earth connections, brass bolts and nuts with lead washers are provided in the pipes/plates;
15) Earth pipe troughs and oil sumps/pits are free from rubbish and dirt and stone jelly and the earth connections are visible and easily accessible;
16) HT and LT panels are switchgears are all vermin and damp-proof and all unused openings or holes are blocked properly;
17) The earth bus bars have tight connections and corrosion-free joint surfaces;
18) Operating handle of protective device are provided at an accessible height from ground;
19) Adequate headroom is available in the transformer room for easy topping-up of oil, maintenance, etc.
20) Safety devices, horizontal and vertical barriers, bus bar covers/shrouds, automatic safety shutters/doors interlock, handle interlock are safe and in reliable operation in all panels and cubicles;
21) Clearances in the front, near and sides of the main HV and MV and sub-switch boards are adequate;
22) The switches operate freely; the 3 blades make contact at the same time, the arcing horns contact in advance; and the handles are provided with locking arrangements;
23) Insulators are free from cracks, and are clean;
24) In transformers, there is any oil leak;
25) Connections to bushing in transformers for tightness and good contact;
26) Bushings are free from cracks and are clean;
27) Accessories of transformers like breathers, vent pipe, Buchholz relay, etc. are in order;
28) Connections to gas relay in transformers are in order;
29) Oil and winding temperature are set for specific requirements in transformers;
30) In case of cable cellars, adequate arrangements to pump out water that has entered due to seepage or other reasons;
31) All incoming and outgoing circuits of HV and MV panels are clearly and indelibly labeled for identifications;
32) No cable is damaged;
33) There is adequate clearance around the equipments installed; and
34) Cable terminations are proper.

28.11.2.2.2 Medium voltage installation

In medium voltage installations, it shall be checked whether:

1) All blocking materials that are used for safe transportation in switchgears, contactors, relays, etc. are removed;
2) All connections to be earthing system are feasible for periodical inspection;
3) Sharp cable bends are avoided and cables are taken in a smooth
manner in the trenches or alongside the walls and ceilings using suitable support clamps at regular intervals;

4) Suitable linked switch or circuit breaker or lockable push button is provided near the motors/apparatus in an easily accessible location;

5) Two separate and distinct earth connections are provided for the motor/apparatus;

6) Control switch-fuse is provided at an accessible height form ground for controlling supply to overhead travelling crane, hoists, overhead bus bar trunking;

7) The metal rails on which the crane travels are electrically continuous and earthed and bonding of rails and earthing at both ends are done;

8) Four core cables are used for overhead travelling crane and portable equipments, the fourth core being used for earthing, and separate supply for lighting circuit is taken;

9) If flexible metallic hose is used for wiring to motors and other equipment, the wiring is enclosed to the full lengths, and the hose secured properly by approved means;

10) The cables are not taken through areas where they are likely to be damaged or chemically affected;

11) The screens and armours of the cables are earthed properly;

12) The belts of the belt driven equipments are properly guarded;

13) Adequate precautions are taken to ensure that no live parts are so exposed as to cause danger;

14) Ammeters and voltmeters are tested;

15) The relays are inspected visually by moving covers for deposits of dusts or other foreign matter;

16) Wherever bus ducts/rising mains/overhead bus trunking are used, special care should be taken for earthing the system. All tap off points shall be provided with adequately rated protective device like MCB, MCCB, fuses, ELCB, RCCB, etc.

17) All equipments shall be weather, dust and vermin proof; and

18) Any and all equipments having air insulation as media shall maintain proper distances between phases, phase to neutral; phase to earth and earth to neutral.

28.11.2.2.3 Overhead lines
For overhead lines it shall be checked whether:

1) All conductors and apparatus including live parts thereof are inaccessible;

2) The types and size of supports are suitable for the overhead lines/conductors used and are in accordance with approved drawing and standards;

3) Clearances from ground level to the lowest conductor of overhead lines, sag, etc, are in accordance with the relevant standard;

4) Where overhead lines cross the roads or cross each other or are in proximity with one another, suitable guarding is provided at road crossings and also to protect against possibility of the lines coming in contact with one another;

5) Every guard wire is properly earthed;

6) The type, size and suitability of the guarding arrangement provided is adequate;

7) Stays are provided suitably on the overhead lines as required and are efficiently earthed or provided with suitably stay insulators of suitable voltages;

8) Anti-climbing devices and Danger Board/Caution Board Notices are provided on all HT supports;

9) Clearances along the route are checked and all obstructions such as trees/branches and shrubs are cleared on the route to the required distance on either side;

10) Clearance between the live conductor and the earthed metal parts are adequate;

11) For the service connections tapped-off from the overhead lines, cut-outs of adequate capacity are provided;
12) All insulators are properly and securely mounted; also they are not damaged;
13) All poles are properly grouted/insulated so as to avoid bending of pole towards tension; and
14) Steel poles, if used shall be properly earthed.

28.11.2.4 Lighting circuits

The lighting circuits shall be checked whether:

1) Wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls, etc.;
2) Neutral links are provided in double pole switch-fuses which are used for lighting control, and no protective devices (such as MCB, MCCB, fuses, ELCB, etc) is provided in the neutral;
3) The plug points in the lighting circuit are all of 3-pin type, the third pin being suitably earthed;
4) Tamper-proof interlocked switch socket and plug are used for locations readily accessible;
5) Lighting wiring in factory area is taken enclosed in conduit and conduit properly earthed, or alternatively, armoured cable wiring is used;
6) A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipments;
7) Proper connectors and junction boxes are used wherever joints are to be made in conductors or cross-over of conductors takes place;
8) Cartridge fuse units are fitted with cartridge fuses only;
9) Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary;
10) The polarity having been checked and all protective devices (such as MCB, MCCB, fuses, ELCB, etc) and single pole switches are connected on the phase conductor only and wiring is correctly connected to socket-outlets;
11) Spare knockouts provided in distribution boards and switch fuses are blocked;
12) The ends of conduits enclosing the wiring leads are provided with ebonite or other suitable bushes;
13) The fittings and fixtures used for outdoor use are all of weather-proof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area, are of flame-proof application;
14) Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals;
15) Flat ended screws are used for fixing conductor to the accessories;
16) Use of flat washers backed up by spring washers for making end connections is desirable; and
17) All metallic parts of installation such as conduits, distribution boards, metal boxes, etc. have been properly earthed.

28.11.3 Testing of installation

28.11.3.1 General

After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation in an already existing installation shall commence after obtaining permit to work from the engineer-in-charge and after ensuring the safety provisions.

28.11.3.2 Testing

28.11.3.2.1 Switchboards

HV and MC switchboards shall be tested in the manner indicated below:

a) All high voltage switchboards shall be tested for dielectric test as per good practice.
b) All earth connections shall be checked for continuity.
c) The operation of the protective devices shall be tested by means of secondary or primary injection tests.
d) The operation of the breakers shall be tested from all control stations.
e) Indication/signaling lamps shall be checked for proper working.
f) The operation of the breakers shall be tested for all interlocks.
g) The closing and opening timings of the breakers shall be tested wherever required for auto-transfer schemes.
h) Contact resistance of main and isolator contacts shall be measured.
j) The specific gravity and the voltage of the control battery shall be measured.

28.11.3.2.2 Transformers
Transformers are tested in the manner indicated below:

a) All commissioning tests shall be in accordance with good practice.

b) Insulation resistance on HV and MV windings shall be measured at the end of 1 min as also at the end of 10 min of measuring the polarization index. The absolute value of insulation resistance should not be the sole criterion for determining the state of dryness of the insulation. Polarization index values should form the basis for determining the state of dryness of insulation. For any class of insulation, the polarization index should be greater than 1.5.

28.11.3.2.3 Cables
Cable installations shall be checked as below:

a) It shall be ensured that the cables conform to the relevant Indian Standards. Tests shall also be done in accordance with good practice. The insulation resistance before and after the tests shall be checked.

b) The insulation resistance between each conductor and against earth shall be measured. The insulation resistance varies with the type of insulation used and with the length of cable. The following empirical rule gives reasonable guidance:

\[
\text{Insulation resistance in megaohms (MΩ)} = \frac{10 \times \text{Voltage in kV}}{\text{Length in km}}
\]

c) Physical examination of cables shall be carried out.
d) Cable terminations shall be checked.
e) Continuity test shall be performed before charging the cable with current.

28.11.3.2.4 Motors and other equipment
The following test is made on motor and other equipment:

The insulation resistance of each phase winding against the frame and between the windings shall be measured. Megger of 500 V or 1000 V rating shall be used. Star points should be disconnected. Minimum acceptable value of the insulation resistance varies with the rated power and the rated voltage of the motor.

The following relation may serve as a reasonable guide:

\[
R = \frac{20 \times E_n}{1000 + 2P}
\]

Where

\[
R_i = \text{Insulation resistance in megaohms at } 25^\circ\text{C.}
\]

\[
E_n = \text{Rated phase to phase voltage}
\]

\[
P = \text{Rated power in kW.}
\]

If the resistance is measured at a temperature different from 25°C, the value shall be corrected to 25°C.

The insulation resistance as measured at ambient temperature does not always give a
reliable value, since moisture might have been absorbed during shipment and storage. When the temperature of such a motor is raised, the insulation resistance will initially drop considerably, even below the acceptable minimum. If any suspicion exists on this score, motor winding must be dried out.

28.11.3.2.5 Wiring insulation
The following tests shall be done:

a) The insulation resistance shall be measured by applying between earth and the whole system of conductor or any clause thereof with all fuses in place and all switches closed, and except in earthed concentric wiring, all lamps in position or both poles of installation otherwise electrically connected together, a dc voltage of not less than twice the working voltage, provided that it does not exceed 500 V for medium voltage circuits. Where the supply is derived from three-wire (ac or dc) or a poly-phase system, the neutral pole of which is connected to earth either direct or through added resistance the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.

b) The installation resistance in megohms of an installation measured as in (a) shall be not less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one megaohm.

c) Control rheostats, heating and power appliances and electric signs, may, if desired, be disconnected from the circuit during the test, but in that event the insulation resistance between the case of framework, and all live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard specification or where there is no such specification, shall not be not less than half a megaohm.

d) The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the neutral on to the other pole of phase conductors of the supply. Such a test shall be made after removing all metallic connections between the two poles of the installation and in these circumstances the insulation resistance between conductors of the insulation shall be not less than that specified in (b).

28.11.3.2.6 Completion certificate
On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, counter-signed by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in a prescribed form as required by the local electric supply authority. One such recommended form is given in Annex E.

28.11.3.2.7 Earthing
For checking the efficiency of earthing, the following tests are done:

a) The earth resistance of each electrode shall be measured;

b) Earth resistance of earthing grid shall be measured;

These tests shall preferably be done during the summer months.

28.12 TELECOMMUNICATION AND OTHER MISCELLANEOUS SERVICES
28.12.1 Telecommunication service
28.12.1.1 House wiring of telephone subscribers offices in small buildings is normally undertaken by the Telephone Department on the surface of walls. But in large multi-storeyed buildings intended for commercial, business and office use as well as for residential purposes, wiring for telephone connections is generally done in a concealed manner through conduits.

28.12.1.2 The requirements of telecommunication facilities like telephone
connections, private branch exchange, intercommunication facilities, telex and telegraph lines are to be planned well in advance so that suitable provisions are made in the building plan in such a way that the demand for telecommunication services in any part of the building at any floor are met at any time during the life of the building.

28.12.1.3 Layout arrangements, methods for internal block wiring and other requirements regarding provisions of space, etc. may be decided defending as the number of phone outlets and other details in consultation with Engineer/Architect and user.

28.12.2 Public address system (See Part 3- ‘Use and Occupancy’)

28.12.3 Common antenna system for TV receivers

28.12.3.1 In multi-storeyed apartments, houses and hotels where many TV receivers are located, a common master antenna system may preferably be used to avoid mushrooming of individual antennas.

28.12.3.2 Master antenna is generally provided at the top most convenient point in any building and a suitable room on the top-most floor or terrace for housing the amplifier unit, may also be provided in consultation with the architect/engineer.

28.12.3.3 From the amplifier rooms, conduits are laid in recess to facilitate drawing coaxial cable to individual flats. Suitable ‘Tap Off’ boxes may be provided in every room/flat as required.

28.12.4 UPS system

The UPS is an electrical device providing an interface between the mains power supply and sensitive loads (computer systems, instrumentation, etc.). The UPS supplies sinusoidal a.c power free of disturbances and within strict amplitude and frequency tolerances. It is generally made up of a rectifier/charger and an inverter together with a battery for backup power in the event of a mains failure with virtually no time lag.

In general UPS system shall be provided for sensitive electronic equipments like computers, printers, fire alarm panel, public address system equipment, access control panel, EPABX, etc. with the following provisions:

a) Provisions of isolation transformers shall be provided where the capacity exceeds 5 kVA.

b) UPS shall have dedicated neutral earthing system.

c) Adequate rating of protective devices such as MCB, MCCB, fuses, ELCB, etc. shall be provided at both incoming and outgoing sides.

d) UPS room shall be provided with adequate ventilation and/or air conditioning as per requirement.

28.12.5 Inverter

In general, an inverter system shall be provided for house lighting, shop lighting, etc. with the following provisions:

a) Adequate rating of protective devices such as MCB, MCCB, fuses, ELCB, etc. shall be provided at both incoming and outgoing sides.

b) Earthing shall be done properly.

c) Adequate ventilation space shall be provided around the battery clause of the inverter.

d) Care in circuit design to keep the connected load in such a manner that the demand at the time of mains failure is within the capability of the inverter. (If the inverter fails to take cover the load at the time of the mains failure, the purpose of providing the inverter and battery backup is defeated).

e) Circuits which are fed by the UPS or Inverter systems should have suitable marking to ensure that a workman does not assume that the power is off, once he has switched off the mains from the DB for maintenance.

f) UPS systems and Inverter systems have a very limited fault feeding capacity in comparison to the mains supply from the licensee’s network. The low fault current feed may cause loss of
discrimination in the operation of MCB’s, if the inverter on UPS system feeds a number of circuits with more than one over current protective device in series (such as incoming MCB at the DB and a few outgoing MCB’s). The choice of MCB’s in such cases has to be done keeping the circuit operating and fault condition parameters under both (mains operation and UPS operation) conditions.

28.12.6 Diesel generating set (less than 5 kVA)

In general small diesel generating sets shall be provided for small installations such as offices, shops, small scale industry, hostels, etc. with the following provisions:

a) These shall be located near the exit or outside in open areas
b) They shall be in reach of authorized persons only
c) Adequate firefighting equipment shall be provided near such installations
d) Exhaust from these shall be disposed in such a way so as not to cause health hazard.
e) These shall have acoustic enclosure, or shall be placed at a location so as not to cause noise pollution.
f) Adequate ventilation shall be provided around the installation
g) Adequate rating of protective devices such as MCB, MCCB, fuses, ELCB, etc. shall be provided
h) Separate and adequate body and neutral earthings shall be done.

28.12.7 Building management system

A building management/automation system may be considered to be provided for controlling and monitoring of all parameters of HVAC, electrical, plumbing, fire fighting, low voltage system such as telephone, TV, etc. This not only lead to reduction of energy consumption, it shall also generate data leading to better operation practice and systematic maintenance scheduling. The total overview provided by a Building Automation System, with a capability to oversee a large number of operating and environmental parameters on real time basis leads to introduction of measures which lead to further reduction in energy consumption.

It shall also help in reduction of skilled manpower required for operation and maintenance of large complexes. This system can further linked to other systems such as Fire alarm system, public address system, etc. for more effective running of services.

This system can be used for analysis and controlling of all services in a particular complex, leading efficient and optimum utilization of available services.

28.12.8 Security system

Security system may be defined as an integrated Closed Circuit Television System, Access Control System, Perimeter Protection Systems, movement sensors, etc. These have a central control panel, which has a defined history storage capacity. This main control panel may be located near to the fire detection and alarm system.

These may be considered for high security areas or large crowded areas or complexes. High security areas may consider uncorded, high-resolution, black and white cameras in place of coloured cameras. These may be accompanied with movement sensors.

Access control may be provided for entry to high security areas. The systems may have proximity card readers, magnetic readers, etc.

28.12.9 Computer networking

Networking is the practice of linking computing devices together with hardware and software that supports data communication across these devices.

28.12.10 Car part management system

The Car management System may be provided in multi-level parking or other parking plots where number of vehicles to be parked exceeds 1000 vehicles. The Car Park Management System may have features of Pay and Display Machines may be manned and unmanned type. Parking guidance system needs to display number of car spaces vacant on various floors, direction of entry and exit, etc. This system can be of great benefit in evaluating statistical data's
such as number of cars in a day or month or hour, stay time of various vehicles, etc.

28.13 LIGHTENING PROTECTION OF BUILDINGS

28.13.1 Basic consideration for protection

Before proceeding with the detailed design of a lightening protecting system, the following essential steps should be taken:

a) Decide whether or not the structure needs protection and, if so, what are the special requirements (see 28.13.1.1)

b) Ensure a close liaison between the architect, the builder, the lightening protective system engineer, and the appropriate authorities throughout the design stages.

c) Agree the procedures for testing, commissioning and future maintenance.

28.13.1.1 Need for protection

Structures with inherent explosive risks; for example, explosives factories, stores and dumps and fuel tanks; usually need the highest possible class of lighting protective system.

For all other structures, the standard of protection recommended in the remainder of the Code is applicable and the only question remaining is whether to protect or not.

In many cases, the need for protection may be self-evident, for example:

- Where large numbers of people congregate;
- Where essential public services are concerned;
- Where the area is one in which lighting strokes are prevalent;
- Where there are very tall or isolated structures and
- Where there are structures of historic or cultural importance.

However, there are many cases for which a decision is not so easy to make. Various factors effecting risk of being struck and the consequential effects of a stroke in these cases are discussed in 28.13.1.2 to 28.13.1.8.

It must be understood, however, that some factors cannot be assessed, and these may override all other considerations. For example, a desire that there should be no avoidable risk to life or that the occupants of a building should always feel safe, may decide the question in favour of protection, even though it would normally be accepted that there was no need. No guidance can be given in such matters, but an assessment can be made taking account of the exposure risk (that is the risk of the structure being struck) and the following factors:

a) Use to which the structure is put;
b) Nature of its construction;
c) Value of its contents or consequential effects;
d) The height of the structure (in the case of composite structures the overall height).

28.13.1.2 Estimation of exposure risk

The probability of a structure or building being struck by lightning in any one year is the product of the ‘lightening flash density’ and the ‘effective collection area’ of the structure. The lightning flash density, \( N_g \), is the number of (flashes to ground) per km\(^2\) per year.

**Note:** For the purpose of this Code, the information given in Fig.5 on thunderstorm days per year would be necessary to be translated in terms of estimated average annual density \( N_g \).

The table below which indicates the relationship between thunderstorm days per year and lightning flashes per square kilometer per year:

<table>
<thead>
<tr>
<th>Thunderstorm days/year</th>
<th>Lightning Flashes per km(^2) per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
</tr>
<tr>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>20</td>
<td>1.1</td>
</tr>
<tr>
<td>30</td>
<td>1.9</td>
</tr>
<tr>
<td>40</td>
<td>2.8</td>
</tr>
<tr>
<td>50</td>
<td>3.7</td>
</tr>
<tr>
<td>60</td>
<td>4.7</td>
</tr>
<tr>
<td>80</td>
<td>6.9</td>
</tr>
<tr>
<td>100</td>
<td>9.2</td>
</tr>
</tbody>
</table>
The effective collection area of a structure is the area on the plan of the structure extended in all dimensions on the plan of the structure extended in all directions to take account of its height. The edge of the effective collection area is displaced from the edge of the structure by an amount equal to the height of the structure at that point. Hence, for a simple rectangular building of length $L$, width $W$ and height $H$ metres, the collection area has length $(L + 2h)$ metres and width $(W + 2h)$ metres with four rounded corners formed by quarter circles of radius $H$ metres. This gives a collection area, $A_c$ (in m$^2$).

$$A_c = (L \times W) + 2 (L \times H) + 2 (W \times H) + \pi H^2 \quad \ldots \quad (1)$$

The probable number of strikes (risk) to the structure per year is:

$$P = A_c \times N_3 \times 10^{-6}$$

It must first be decided whether this risk $P$ is accepted or whether some measure of protection is thought necessary.

28.13.3 Suggested accepted risk

For the purposes of this Code, the acceptable risk Figure has been taken as $10^{-5}$, that is, 1 in 100,000 per year.

28.13.4 Overall assessment of risk

Having established the value of $P$, the probable number of strikes to the structure per year [see equation (2) in 28.12.1.2] the next step is to apply the ‘weighting factors’ in Table3 and 4.

This is done by multiplying $P$ by the appropriate factors to see whether the result, the overall weighting factors, exceeds the acceptable risk of $P = 10^{-5}$ per year.

28.13.5 Weighting factors

In Tables 3A to 3E, the weighting factor values are given under headings ‘A’ to ‘E’, denoting a relative degree of importance or risk in each case. The tables are mostly self-explanatory but it may be helpful to say something about the intention of Table 3C.

### Table 3: Overall assessment of risk

(28.12.1.4 and 28.12.1.5)

### Table 3A: Weighting factor ‘A’; - (Use of structure)

<table>
<thead>
<tr>
<th>Use to which structure is put</th>
<th>Value of ‘A’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houses and other buildings of comparable size</td>
<td>0.3</td>
</tr>
<tr>
<td>Houses and other buildings of comparable size with outside aerial</td>
<td>0.7</td>
</tr>
<tr>
<td>Factories, workshops and laboratories</td>
<td>1.0</td>
</tr>
<tr>
<td>Office blocks, hotels, blocks of flats and other residential buildings other than those included below</td>
<td>1.2</td>
</tr>
<tr>
<td>Places of assembly, for example, churches, halls, theatres, museums, exhibitions, departmental stores, post offices, stations, airports and stadium structures</td>
<td>1.3</td>
</tr>
<tr>
<td>Schools, hospitals, children’s and other homes</td>
<td>1.7</td>
</tr>
</tbody>
</table>
### Table 3B: Weighting factor ‘B’ - (Type of construction)

<table>
<thead>
<tr>
<th>Type of construction</th>
<th>Value of ‘B’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel framed encased with any roof other than metal 1)</td>
<td>0.2</td>
</tr>
<tr>
<td>Reinforced concrete with any roof other than metal</td>
<td>0.4</td>
</tr>
<tr>
<td>Steel framed encased or reinforced concrete with metal roof</td>
<td>0.8</td>
</tr>
<tr>
<td>Brick, plain concrete or masonry with any roof other than metal or thatch</td>
<td>1.0</td>
</tr>
<tr>
<td>Timber framed or clad with any roof other than metal or thatch</td>
<td>1.4</td>
</tr>
<tr>
<td>Brick, plain concrete, masonry, timber framed but with metal roofing</td>
<td>1.7</td>
</tr>
<tr>
<td>Any building with a thatched roof</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Note:** 1) A structure of exposed metal which is continuous down to ground level is excluded from these tables as it requires no lighting protection beyond adequate earthing arrangements.

### Table 3C: Weighting factor ‘C’ - (Contents or consequential effects)

<table>
<thead>
<tr>
<th>Contents or consequential effects</th>
<th>Value of ‘C’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary domestic or office buildings, factories and workshops not containing valuable or specially susceptible contents</td>
<td>0.3</td>
</tr>
<tr>
<td>Industrial and agricultural buildings with specially susceptible 1) contents</td>
<td>0.8</td>
</tr>
<tr>
<td>Power stations, gas works, telephone exchanges, radio stations</td>
<td>1.0</td>
</tr>
<tr>
<td>Industrial key plants, ancient monuments and historic buildings with specially valuable contents</td>
<td>1.3</td>
</tr>
<tr>
<td>Schools, hospitals, children's and other homes, places of assembly</td>
<td>1.7</td>
</tr>
</tbody>
</table>

**Note:**

1) This means specially valuable plant or materials vulnerable to fire or the results of fire.
Table 3D: Weighting factor ‘D’ - (Degree of isolation)

<table>
<thead>
<tr>
<th>Degree of isolation</th>
<th>Value of ‘D’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure located in a large area of structures or trees of the same or greater height, for example, in a large town or forest</td>
<td>0.4</td>
</tr>
<tr>
<td>Structure located in an area with few other structures or trees of similar height</td>
<td>1.0</td>
</tr>
<tr>
<td>Structure completely or exceeding at least twice the height of surrounding structures or trees</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Table 3E: Weighting factor ‘E’ - (Type of country)

<table>
<thead>
<tr>
<th>Type of country</th>
<th>Value of ‘E’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat country at any level</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The effect of the value of the contents of a structure is clear the term ‘consequential effect’ is intended to cover not only material risks to goods and property but also such aspects as the disruption of essential services of all kinds, particularly in hospitals.

The risk to life is generally very small, but if a building is struck, fire or panic can naturally result. All possible steps should, therefore, be taken to reduce these effects, especially among children, the old, and the sick.

28.13.1.6 Interpretation of overall risk factor

The risk factor method put forward here is to be taken as giving guidance on what might, in some cases, be a difficult problem. If the result obtained is considerably less than $10^{-5}$ (in 100,000) then, in the absence of other overriding considerations, protection does not appear necessary; if the result is greater than $10^{-5}$, say for example $10^{-4}$ (1 in 10,000) then sound reasons would be needed to support a decision not to give protection.

When it is thought that the consequential effects will be small and that the effect of a lighting stroke will most probably be merely slight damage to the fabric of the structure, it may be economic not to incur the cost of protection but to accept the risk. Even though, this decision is made, it is suggested that the calculation is still worthwhile as giving some idea of the magnitude of the calculated risk being taken.

28.13.1.7 Anomalies

Structures are so varied that any method of assessment may lead to anomalies and those who have to decide on protection must exercise judgement. For example, a steel-framed building may be found to have a low risk factor but, as the addition of an air termination and earthing system will give greatly improved protection, the cost of providing this may be considered worthwhile.
A low risk factor may result for chimneys made of brick or concrete. However, where chimneys are free standing or where they project for more than 4.5m above the adjoining structure, they will require protection regardless of the factor. Such chimneys are, therefore, not covered by the method of assessment. Similarly, structures containing explosives or flammable substances are also not covered.

Results of calculations for different structures are given in Table 8 and a specific case is worked through in 28.13.1.8.

28.13.1.8 Sample calculation of need for protection

A hospital building is 10m high and covers an area of 70m x 12m. The hospital is located in a flat country and isolated from other structures. The construction is of brick and concrete with a non-metallic roof.

a) Flashes/km²/year – Let us say, for the protection of the hospital a value for \( N_g \) is 0.7.


\[
A_c = (70 \times 12) + 2(70 \times 10) + 2(12 \times 10) + (\pi \times 100)
\]

\[
= 840 + 1400 + 240 + 314
\]

\[
= 2794 \text{ m}^2
\]

c) Probability of being struck – Using equation (2) in 28.13.1.2:

\[
P = \frac{A_c \times N_g \times 10^{-6}}{\text{times per year}}
\]

\[
= \frac{2794 \times 0.7 \times 10^{-6}}{\text{times per year}}
\]

\[
= 2.0 \times 10^{-5} \text{ appropriately}
\]

d) Applying the weighting factors

\[
A = 1.7
\]

\[
B = 1
\]

\[
C = 1.7
\]

\[
D = 2.0
\]

\[
E = 0.3
\]

The overall multiplying factor

\[
= A \times B \times C \times D \times E
\]

\[
= 1.7
\]

Therefore, the overall risk factor

\[
= 2.0 \times 1.7 \times 10^{-3}
\]

\[
= 3.4 \times 10^{-3}
\]

Conclusion: Protection is necessary.

28.13.2 For detailed requirements of lighting protection of various structures, reference may be made to good practice.
Table 4 – Examples of calculations for evaluating the need for protection

<table>
<thead>
<tr>
<th>SI</th>
<th>Description</th>
<th>Risk of being struck (P)</th>
<th>Weighting factors</th>
<th>Overall multiplying factor (Product of Cols. 6-10)</th>
<th>Overall risk factor (product of Cols 5 and 11)</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Malsonette, reinforced concrete and brick built, non-metallic roof</td>
<td>$P = \frac{A_c}{N_g} \times 10^6$</td>
<td>‘A’ Use of Structure (Table 3A)</td>
<td>0.92</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>(2)</td>
<td>Office building, reinforced concrete construction, non-metallic roof</td>
<td>$P = \frac{A_c}{N_g} \times 10^6$</td>
<td>‘B’ Type of Construction (Table 3B)</td>
<td>1.2</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>(3)</td>
<td>School, brick built</td>
<td>$P = \frac{A_c}{N_g} \times 10^6$</td>
<td>‘C’ Contents or consequential effects (Table 3C)</td>
<td>1.7</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>(4)</td>
<td>3 bedroom detached dwelling house, brick built</td>
<td>$P = \frac{A_c}{N_g} \times 10^6$</td>
<td>‘D’ Degree of isolation (Table 3D)</td>
<td>0.3</td>
<td>1.0</td>
<td>0.3</td>
</tr>
<tr>
<td>(5)</td>
<td>Village church</td>
<td>$P = \frac{A_c}{N_g} \times 10^6$</td>
<td>‘E’ Type of Country (Table 3E)</td>
<td>1.3</td>
<td>1.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

*Note: The risk of being struck, ‘P’ (col 5), is multiplied by the product of the weighting factors (col 6 to 10) to yield an overall risk factor (col 12). This should be compared with the acceptable risk ($1 \times 10^{-5}$) for guidance on whether or not to protect.*
APPENDIX A

A-4.4 Combined Switch and Socket-Outlet, 16 A
A-4.5 Interlocking Switch and Socket-Outlet, 6 A
A-4.6 Interlocking Switch and Socket-Outlet, 16 A

A-5 LAMPS AND LIGHTING APPARATUS
A-5.0 Symbols A-5.1 to A-5.17.1 represent either the lamp or a group of lamps or the outlet for lamps. If it is desired to specify that the lamp is fixed to the wall or ceiling, a vertical or horizontal line respectively may be added to the symbol.

A-5.1 Lamp or Outlet for Lamp
A-5.1.1 Group of Three 40-W Lamps 3 x 40 W
A-5.2 Lamp, Mounted on a Wall
A-5.3 Lamp, Mounted on a Ceiling
A-5.4 Counter Weight Lamp Fixture
A-5.5 Chain Lamp Fixture
A-5.6 Rod Lamp Fixture
A-5.7 Lamp Fixtures with Built-in Switch
A-5.8 Lamp Fed from Variable Voltage Supply
A-5.9 Emergency Lamp
A-5.10 Panic Lamp
A-5.11 Bulk-Head Lamp
A-5.12 Water-Tight Lighting Fitting
A-5.13 Batter Lamp Holder
A-5.14 Projector

A-5.15 Spot Light
A-5.16 Flood Light
A-5.17 Flourescent Lamp
A-5.17.1 Group of Three 40-W Fluorescent Lamps

A-6 ELECTRICAL APPLIANCES
A-6.1 General
NOTE — If necessary, use designation is specify.
A-6.2 Heater
A-6.3 Storage Type Electric Water Heaters

A-7 BELLS, BUZZERS AND SIRENS
A-7.1 Bell
A-7.2 Buzzer
A-7.3 Siren
A-7.4 Horn on Hooter
A-7.5 Indicator (at ‘N’ insert number of ways)

A-8 FANS
A-8.1 Ceiling Fan
A-8.2 Bracket Fan
A-8.3 Exhaust Fan
A-8.4 Fan Regulator

A-9 TELECOMMUNICATION APPARATUS
A-9.1 Socket-Outlet for Telecommunications
A-9.2 Aerial
A-9.3 Loudspeaker

963
A-9.4 Radio Receiving Set
A-9.5 Amplifying Equipment
A-9.6 Television Receiving Set
A-9.7 Control Board (for Public Address System)
A-10 CLOCKS
  A-10.1 Synchronous Clock
  A-10.2 Impulse Clock Outlet
  A-10.3 Master Clock Outlet

A-11 FIRE ALARMS
  A-11.1 Manual Operated Fire Alarm
  A-11.2 Automatic Fire Detector Switch
  A-11.3 Bell Connected to Fire Alarm Switch
  A-11.4 Fire Alarm Indicator
A-12 EARTHING
  A-12.1 Earth Point
APPENDIX B

AREA REQUIRED FOR TRANSFORMER ROOM AND SUBSTATION FOR DIFFERENT CAPACITIES

C-1 The requirement for area for transformer room and substation for different capacities of transformers is given below for guidance:

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Capacity of Transformer(s) kVA</th>
<th>Total Transformer Room Area Minimum m²</th>
<th>Total Substation Area (In Coming, HV, MV Panels, Transformer Roof but Without Generators), Minimum</th>
<th>Suggested Minimum Face Width m</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>i)</td>
<td>1 × 160</td>
<td>14.0</td>
<td>90</td>
<td>9.0</td>
</tr>
<tr>
<td>ii)</td>
<td>2 × 160</td>
<td>28.0</td>
<td>118</td>
<td>13.5</td>
</tr>
<tr>
<td>iii)</td>
<td>1 × 250</td>
<td>15.0</td>
<td>91</td>
<td>9.0</td>
</tr>
<tr>
<td>iv)</td>
<td>2 × 250</td>
<td>30.0</td>
<td>121</td>
<td>13.5</td>
</tr>
<tr>
<td>v)</td>
<td>1 × 400</td>
<td>16.5</td>
<td>93</td>
<td>9.0</td>
</tr>
<tr>
<td>vi)</td>
<td>2 × 400</td>
<td>33.0</td>
<td>125</td>
<td>13.5</td>
</tr>
<tr>
<td>vii)</td>
<td>3 × 400</td>
<td>49.5</td>
<td>167</td>
<td>18.0</td>
</tr>
<tr>
<td>viii)</td>
<td>2 × 500</td>
<td>36.0</td>
<td>130</td>
<td>14.5</td>
</tr>
<tr>
<td>ix)</td>
<td>3 × 500</td>
<td>54.0</td>
<td>172</td>
<td>19.0</td>
</tr>
<tr>
<td>x)</td>
<td>2 × 630</td>
<td>36.0</td>
<td>132</td>
<td>14.5</td>
</tr>
<tr>
<td>xi)</td>
<td>3 × 630</td>
<td>54.0</td>
<td>176</td>
<td>19.0</td>
</tr>
<tr>
<td>xii)</td>
<td>2 × 800</td>
<td>39.0</td>
<td>135</td>
<td>14.5</td>
</tr>
<tr>
<td>xiii)</td>
<td>3 × 800</td>
<td>58.0</td>
<td>181</td>
<td>14.0</td>
</tr>
<tr>
<td>xiv)</td>
<td>2 × 1000</td>
<td>39.0</td>
<td>149</td>
<td>14.5</td>
</tr>
<tr>
<td>xv)</td>
<td>3 × 1000</td>
<td>58.0</td>
<td>197</td>
<td>19.0</td>
</tr>
</tbody>
</table>

NOTES

1. The above dimensions are overall area required for substation excluding generating set.
2. The clear height required for substation equipment shall be minimum of 3.0 m below the soffit of the beam.
### APPENDIX C

#### ADDITIONAL AREA REQUIRED FOR GENERATOR IN ELECTRIC SUBSTATION

D-1 The requirement of additional area for generator in electric substation for different capacities of generators is given below for guidance:

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Capacity (kW)</th>
<th>Area (m²)</th>
<th>Clear Height below the Soffit of the Beam (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>i)</td>
<td>25</td>
<td>56</td>
<td>3.6</td>
</tr>
<tr>
<td>ii)</td>
<td>48</td>
<td>56</td>
<td>3.6</td>
</tr>
<tr>
<td>iii)</td>
<td>100</td>
<td>65</td>
<td>3.6</td>
</tr>
<tr>
<td>iv)</td>
<td>150</td>
<td>72</td>
<td>4.6</td>
</tr>
<tr>
<td>v)</td>
<td>248</td>
<td>100</td>
<td>4.6</td>
</tr>
<tr>
<td>vi)</td>
<td>350</td>
<td>100</td>
<td>4.6</td>
</tr>
<tr>
<td>vii)</td>
<td>480</td>
<td>100</td>
<td>4.6</td>
</tr>
<tr>
<td>viii)</td>
<td>600</td>
<td>110</td>
<td>4.6</td>
</tr>
<tr>
<td>ix)</td>
<td>800</td>
<td>120</td>
<td>4.6</td>
</tr>
<tr>
<td>x)</td>
<td>1,000</td>
<td>120</td>
<td>4.6</td>
</tr>
<tr>
<td>xi)</td>
<td>1,250</td>
<td>120</td>
<td>4.6</td>
</tr>
<tr>
<td>xii)</td>
<td>1,600</td>
<td>150</td>
<td>4.6</td>
</tr>
</tbody>
</table>

**NOTE** — The area and height required for generating set room given in the above table are for general guidance only and may be finally fixed according to actual requirements.
# APPENDIX D

I/we certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with the Electricity Company of Ghana Rules.

<table>
<thead>
<tr>
<th>Electrical Installation at</th>
<th>Voltage and system of supply</th>
<th>Particulars of Works:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>a) Internal Electrical Installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>i) Light point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii) Fan point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii) Plug point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-pin 6 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-pin 16 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Others</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1) Motors:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Other plants:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) If the work involves installations of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>over head line and/or underground cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1) i) Type and description of overhead line.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii) Total length and number of spans.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>iii) No. of street lights and its description.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) i) Total length of underground cable and its size:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ii) No. of joints:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>End joint:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tee joint:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Straight through joint:</td>
</tr>
</tbody>
</table>

Earthing:

| i) Description of earthing electrode |  |
| ii) No. of earth electrodes |  |
| iii) Size of main earth lead |  |

Test Results:

| a) Insulation Resistance |  |
| i) Insulation resistance of the whole system of conductors to earth | Megaohms. |
| ii) Insulation resistance between the phase conductor and neutral |  |
| Between phase R and neutral | Megaohms. |
| Between phase Y and neutral | Megaohms. |
| Between phase B and neutral | Megaohms. |
| iii) Insulation resistance between the phase conductors in case of polyphase supply |  |
| Between phase R and phase Y | Megaohms |
| Between phase Y and phase B | Megaohms |
| Between phase B and phase R | Megaohms |
28.14 EMERGENCY AND STANDBY POWER SYSTEMS


Stationary emergency and standby power generators required by this Code shall be listed in accordance with this Code.

Fuel lines supplying a generator set inside a high-rise building shall be separated from areas of the building other than the room the generator is located in by an approved method, or an assembly that has a fire-resistance rating of not less than 2 hours. Where the building is protected throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1, the required fire-resistance rating shall be reduced to 1 hour.

28.14.1.3 Installation.
Emergency power systems and standby power systems required by this Code or the Ghana Fire Code shall be installed in accordance with the Ghana Fire Code, (Ghana Wiring Code).

28.14.1.4 Load transfer.
Emergency power systems shall automatically provide secondary power within 10 seconds after primary power is lost, unless specified otherwise in this Code. Standby power systems shall automatically provide secondary power within 60 seconds after primary power is lost, unless specified otherwise in this Code.

28.14.1.5 Load duration.
Emergency power systems and standby power systems shall be designed to provide the required power for a minimum duration of 2 hours without being refueled or recharged, unless specified otherwise in this Code.

28.14.1.6 Uninterruptable power source.
An uninterrupted source of power shall be provided for equipment where required by the manufacturer's instructions, the listing, this Code or applicable referenced standards.

28.14.1.7 Interchangeability.
Emergency power systems shall be an acceptable alternative for installations that require standby power systems.
In Group I-2 occupancies located in flood hazard areas established in this Code, where new essential electrical systems are installed, and where new essential electrical system generators are installed, the systems and generators shall be located and installed in accordance with this Code. Where connections for hookup of temporary generators are provided, the connections shall be located at or above the elevation required in this Code.

Emergency and standby power systems shall be provided where required by Clause 28.14.2.1 through 28.14.2.18.

28.14.2.1 Ambulatory care facilities.
Essential electrical systems for ambulatory care facilities shall comply with this Code.

28.14.2.2 Elevators and platform lifts.
Standby power shall be provided for elevators and platform lifts as required in this Code.

28.14.2.3 Emergency responder radio coverage systems.
Standby power shall be provided for emergency responder radio coverage systems required in Clause 10.18 and the Ghana Fire Code. The standby power supply shall be capable of operating the emergency responder radio coverage system for a duration of not less than 12 hours at 100-percent system operation capacity.

28.14.2.4 Emergency voice/alarm communication systems.
Emergency power shall be provided for emergency voice/alarm communication systems as required in this Code. The system shall be capable of powering the required load for a duration of not less than 24 hours, as required in Ghana Fire Code.

28.14.2.5 Exhaust systems.
Standby power shall be provided for common exhaust systems for domestic kitchens located in multistorey structures as required in this Code. Standby power shall be provided for common exhaust systems for clothes dryers located in multistorey structures as required in this Code.

28.14.2.6 Exit signs.
Emergency power shall be provided for exit signs as required in Clause 11.13.6.3. The system shall be capable of powering the required load for a duration of not less than 90 minutes.

28.14.2.7 Gas detection system.
Emergency or standby power shall be provided for gas detection systems in accordance with the Ghana Fire Code.

28.14.2.8 Group I-2 occupancies.
Essential electrical systems for Group I-2 occupancies shall be in accordance with Clause 4.7.11.

28.14.2.9 Group I-3 occupancies.
Emergency power shall be provided for power-operated doors and locks in Group I-3 occupancies as required in Clause 4.8.4.2.

Emergency or standby power shall be provided in occupancies with hazardous materials where required by the Ghana Fire Code.

Emergency and standby power shall be provided in high-rise buildings as required in Clause 4.3.4.8.

28.14.2.12 Laboratory suites.
Standby or emergency power shall be provided in accordance with Clause 5004.7 where laboratory suites are located above the sixth storey above grade plane or located in a storey below grand plant.

Emergency power shall be provided for means of escape illumination as required in Clause 11.8.3. The system shall be capable of powering the required load for a duration of not less than 90 minutes.

Standby power shall be provided for auxiliary inflation systems in permanent membrane structures as required in Clause 32.2.8.2. Standby power shall be provided for a duration of not less than 4 hours. Auxiliary inflation systems in temporary air-supported and air-
inflated membrane structures shall be provided in accordance with the Ghana Fire Code.

28.14.2.15 Semiconductor fabrication facilities.
Emergency power shall be provided for semiconductor fabrication facilities as required in Clause 4.15.11.10.

28.14.2.16 Smoke control systems.
Standby power shall be provided for smoke control systems as required in Clauses 4.4.7, 10.9.11, 10.9.20.6.2 and 10.9.21.5.

28.14.2.17 Special purpose horizontal sliding, accordion or folding doors.
Standby power shall be provided for special purpose horizontal sliding, accordion or folding doors as required in Clause 11.10.1.4.3. The standby power supply shall have a capacity to operate not fewer than 50 closing cycles of the door.

Emergency and standby power shall be provided in underground buildings as required in Clause 4.5.

28.14.3 Critical circuits.
Required critical circuits shall be protected using one of the following methods:

1. Cables, used for survivability of required critical circuits and have a fire-resistance rating of not less than 1 hour.
2. Electrical circuit protective systems having a fire-resistance rating of not less than 1 hour. Electrical circuit protective systems are installed in accordance with their listing requirements.
3. Construction having a fire-resistance rating of not less than 1 hour.

Emergency and standby power systems shall be maintained and tested in accordance with the Ghana Fire Code.

PART 29: MECHANICAL SYSTEMS

29.1 GENERAL

29.1.1 Scope.
This clause covers the design, construction and installation of air conditioning and heating systems and equipment installed in buildings for the purpose of providing and maintaining conditions of air temperature, humidity, purity and distribution suitable for the use and occupancy of the space.

In addition, it covers requirements and guidelines regarding planning against noise, acceptable noise levels and the requirements for sound insulation in buildings with different occupancies.

It also covers the requirements regarding the safety of persons and property for all piping uses and for all types of gases used for fuel or lighting purposes in buildings and does not cover safety rules for gas burning appliances.

Exhaust Systems, Boiler and Pressure Vessels, Refrigeration and Solar Thermal Systems are similarly covered under this part.

29.1.2 Definitions

For the purpose of this Clause the following definitions shall apply:

Air conditioning – The process of treating air so as to control simultaneously its temperature, humidity, purity, distribution and air movement and pressure to meet the requirements of the conditioned space.
Ambient Noise — The sound pressure levels associated with a given environment. Ambient noise is usually a composite of sounds from near and far sources none of which are particularly dominant.

Atmospheric pressure - The weight of air column on unit surface area of earth by atmospheric column. At sea level, the standard atmospheric or barometric pressure is 760 mm of mercury (1 033mm of water column/101.325 kPa).

Generally atmospheric pressure is used as a datum for indicating the system pressures in air conditioning and accordingly, pressures are mentioned above the atmospheric pressure or below the atmospheric pressure considering the atmospheric pressure to be zero. A ‘U’ tube manometer will indicate zero pressure when pressure measured is equal to atmospheric pressure.

Audible Frequency Range — The range of sound frequencies normally heard by the human ear. The audible range spans from 20 Hz to 20000 Hz.

A-Weighted Sound Pressure, $P_A$ — Value of overall sound pressure, measured in pascals ($Pa$), after the electrical signal derived from a microphone has been passed through an A-weighting network.

Note: The A-weighting network modifies the electrical response of a sound level meter with frequency in approximately the same way as the sensitivity of the human hearing system.

A-Weighted Sound Pressure Level, $L_{PA}$ — Quantity of A-weighted sound pressure, given by the following formula in decibels (dBA):

$$L_{PA} = 10 \log_{10} \left( \frac{P_a}{P_0} \right)^2$$

Where

$P_A$ = is the A-weighted sound pressure in pascals ($Pa$); and

$P_0$ = is the reference sound pressure (20$\mu$Pa).

Note: Measurements of A-weighted sound pressure level can be made with a meter and correlate roughly with subjective assessments of loudness, and are usually made to assist in judging the effects of noise on people. The size of A-weighting in 1/3 octave bands, is shown in Annex A (see A-5). An increase or decrease in level of 10dBA corresponds roughly to a doubling or halving of loudness.

Background Noise — The sound pressure levels in a given environment from all sources excluding a specific sound source being investigated or measured.

Break-in — Unwanted sound transmission into a duct from outside.

Break-out — Unwanted sound transmission from inside a duct to the outside.

Broad band Noise — Spectrum consisting of a large number of frequency components, none of which is individually dominant.

Buildings Related Illnesses (BRI) — The illness attributed directly to the specific airborne building contaminants like the outbreak of the Legionnaire's disease after a convention and sensitivity pneumonitis with prolonged exposure to the indoor environment of the building. Some of the other symptoms relating to BRI are sensory irritation of eyes, ears and throat, skin irritation, headache, nausea, drowsiness, asthma like symptoms in non-asthmatic persons. The economic consequences of BRI is decreased productivity, absenteeism and the legal implications if occupants IAQ complaints are left unresolved.

Cross — Talk — Unwanted sound transmission between one room and another room or space via a duct.

Decibels — Ten times the logarithm (to the base of the ratio of two mean square values of sound pressure, sound power or sound intensity. The abbreviation for ‘decibels’ is dB.

Dewpoint temperature — The temperature at which condensation of moisture begins when the air is cooled at same pressure.

Dry-bulb temperature — The temperature of the air, read on a thermometer, taken in such a way as to avoid errors due to radiation.

Duct system — A continuous passageway for the transmission of air which, in addition to the ducts, may include duct fittings, dampers, plenums, and grilles and diffusers.

Effective Perceived Noise Level in Decibel (EPN dB) — The number for rating the noise of an individual aircraft flying overhead is the effective perceived noise level in decibels.
(EPN dB). The effective perceived noise decibel value takes into account the subjectively annoying effects of the noise including pure tones and duration. In principle, it is a kind of time-integrated loudness level.

**Enthalpy** – A thermal property indicating the quantity of heat in the air above an arbitrary datum, in kilo Joules per kg of dry air (or in Btu per pound of dry air).

**Evapourative air cooling** – The evapourative air cooling application is the simultaneous removal of sensible heat and the addition of moisture to the air. The water temperature remains essentially constant at the wet-bulb temperature of the air.

**Equivalent Continuous A-Weighted Sound Pressure Level, L_{Aeq,T}** – Value of the A-weighted sound pressure level in decibels (dB) of a continuous, steady sound, that within a specified time interval, T, has the same mean squared sound pressure as the sound under consideration that varies with time, given by the formula:

\[
L_{Aeq,T} = 10 \log_{10} \left\{ \frac{1}{T} \int_{0}^{T} \frac{P_A^2(t)}{P_o^2} \, dt \right\}
\]

Where

- \( P_A(t) \) = is the instantaneous A-weighted sound pressure in pascals (Pa); and
- \( P_o \) = is the reference sound pressure (20\( \mu \) Pa).

**Note:** Equivalent continuous A-weighted sound pressure level is mainly used for the assessment of environmental noise and occupational noise exposure.

**Equivalent Sound Absorption Area of a Room** – A Hypothetical area of a totally absorbing surface without diffraction effects, expressed in square metres (m\(^2\)) which, if it were the only absorbing element in the room, would give the same reverberation time as the room under consideration.

**Façade Level** – Sound pressure level measured 1m to 2m in front of the façade.

**Note:** Façade level measurements of \( L_{PA} \) are usually 2 dB to 3 dB higher than corresponding free-field measurements.

**Free-Field Level** – Sound pressure level measured outside, far away from reflecting surfaces.

**Note:** Measurements made 1.2m to 1.5m above the ground and at least 3.5m away from other reflecting surfaces are usually regarded as being free-field measurements. To minimize the effect of reflections the measuring position should be at least 3.5m to the side of the reflecting surface (that is, not 3.5m from the reflecting surface in the direction of the source). Estimates of noise from aircraft overhead usually include a correction of dB to allow for reflection from the ground.

**Frequency** – The number of cyclical variations per unit time. Frequency is generally expressed in cycles per second (cps) and is also denoted as Hertz (Hz).

**Fire damper** – A closure which consists of a normally held open damper installed in an air distribution system or in a wall or floor assembly and designed to close automatically in the event of a fire in order to maintain the integrity of the fire separation.

**Fire separation wall** – The wall providing complete separation of one building form another or part of a building from another part of the same building to prevent any communication of fire or heat transmission to wall itself which may cause or assist in the combustion of materials of the side opposite to that portion which may be on fire.

**Global Warming Potential (GWP)** – The potential of a refrigerant to contribute to global warming. Global warming can make our planet and its climate less hospitable and more hostile to human life, thus necessitating reduction in emission of greenhouse gases such as CO\(_2\), SO\(_x\), NO\(_x\) and refrigerants. Long atmospheric life time of refrigerants results in global warming unless the emissions are controlled.

GWP values of some of the refrigerants are given below:

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>GWP Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) R-12</td>
<td>10 6000</td>
</tr>
<tr>
<td>ii) R-22</td>
<td>1 900</td>
</tr>
<tr>
<td>iii) R-134a</td>
<td>1 600</td>
</tr>
<tr>
<td>iv) R-123</td>
<td>120</td>
</tr>
<tr>
<td>v) R-407c</td>
<td>1 980</td>
</tr>
</tbody>
</table>
vi) R-407a  2,340  

The values indicated above are for an integration period of 100 years.

**Hydronic systems** – The water systems that convey heat to or from a conditioned space or process with hot or chilled water. The water flows through piping that connects a chiller or the water heater to suitable terminal heat transfer units located at the space or process.

**Indoor Air Quality (IAQ)** - Air quality that refers to the nature of conditioned air that circulates throughout the space/area where one works or lives, that is, the air one breathes when indoors.

It not only refers to comfort which is affected by temperature, humidity, air movement and odours but also to harmful biological contaminants and chemicals present in the conditioned space. Poor IAQ may be serious health hazard. Carbon dioxide has been recognized as the surrogate ventilation index.

**Infiltration/Exfiltration** – The phenomenon of outside air leaking into/out of an air conditioned space.

**Indoor Ambient Noise** – Pervasive noise in a given situation at a given time, usually composed of noise from many sources, inside and outside the building, but excluding noise from activities of the occupants.

**Impact Sound Pressure Level, **$L_I$** – Average sound pressure level in a specific frequency band in a room below a floor, when it is excited by a standard tapping machine.**

**Insertion Loss (L$_{IL}$)**

Insertion loss is generally defined as the difference, in decibels, between two sound pressure levels (or power levels or intensity levels) which are measured at the same point in space before and after a muffler or any other noise control device is inserted between the measurement point and the noise source.

**Noise** – Unwanted sound which may be hazardous to health, interferes with communications or is disturbing.

**Noise Exposure Forecast (NEF)** – The noise exposure forecast at any location is the summation of the noise levels in EPN dB from all aircraft types, on all runways, suitably weighted for the number of operations during day time and night time.

**Noise Rating (NR)** – Graphical method for rating a noise by comparing the noise spectrum with a family of noise rating curves.

**Note:** Noise rating is described in Annex C.

**Noise Reduction Co-efficient (NRC)**

A single figure descriptor of the sound absorption property of a material. It is the arithmetic mean of the sound absorption coefficients at 250, 500, 1000 and 2000 Hz rounded off to the nearest multiple of 0.05.

**Normalized Impact Sound Pressure Level, **$L_n$** – Impact sound pressure level normalized for a standard absorption area in the receiving room.**

**Note:** Normalized impact sound pressure level is usually used to characterize the insulation of a floor in a laboratory against impact sound in a stated frequency band (see Appendix B).

**Octave Band** – Band of frequencies in which the upper limit of the band is twice the frequency of the lower limit.

**Ozone Depletion Potential (ODP)** – The potential of refrigerant or gases to deplete the ozone in the atmosphere.

The ODP values for various refrigerants are given below:

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>ODP</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-11</td>
<td>1.000</td>
</tr>
<tr>
<td>R-12</td>
<td>0.820</td>
</tr>
<tr>
<td>R-22</td>
<td>0.050</td>
</tr>
<tr>
<td>R-123</td>
<td>0.012</td>
</tr>
<tr>
<td>R-134a</td>
<td>0.000</td>
</tr>
<tr>
<td>R-407a</td>
<td>0.000</td>
</tr>
<tr>
<td>R-407c</td>
<td>0.000</td>
</tr>
<tr>
<td>R-410a</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Due to high ODP or R-11, R-12 and R-22, their use in the air conditioning and refrigeration is being phased-out. R-123 is also in the phase-out category of refrigerants.

**Percentile Level, **$L_{AN,T}$** – A-weighted sound pressure level obtained using time-weighting**
‘F’, which is exceeded for N percent of a specified time interval.

Example:

\( L_{A90,1h} \) is the A-weighted level exceeded for 90 percent of 1 h. Percentile levels determined over a certain time interval cannot accurately be extrapolated to other time intervals. Time-weighting ‘F’ or ‘S’ can be selected on most modern measuring instruments and used to determine the speed at which the instrument responds to changes in the amplitude of the signal. Time-weighting ‘F’ is faster than ‘S’ and so its use can lead to higher values when rapidly changing signals are measured.

**Pink Noise** – Sound with an uninterrupted frequency spectrum and a power which is steady within frequency band and proportional to centre frequency band and proportional to centre frequency. An example is constant power level per octave band.

**Plenum** – An air compartment or chamber to which one or more ducts are connected and which forms part of an air distribution system.

The pressure drop and air velocities in the plenum should be low. Generally, the velocity in plenum should not exceed 1.5 m/s to 2.5 m/s.

**Positive ventilation** – The supply of outside air by means of a mechanical device, such as a fan.

**Psychrometry** – The science involving thermodynamic properties of moist air and the effect of atmospheric moisture on materials and human comfort. It also includes methods of controlling thermal properties of moist air.

**Psychrometric chart** – A chart graphically representing the thermodynamic properties of moist air.

**Pure Tone** – A sound emitted at a single frequency.

**Rating Level, \( L_{Ae}, T \)** – Equivalent continuous A-weighted sound pressure level of the noise, plus any adjustment for the characteristic features of the noise.

**Note:** This definition is used for rating industrial noise, where the noise is the specific noise from the source under investigation.

**Recirculated air** – The return air that has been passed through the conditioning apparatus before being re-supplied to the space.

**Refrigerant** – The fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and low pressure of the fluid and rejects heat at a higher temperature and higher pressure of the fluid, usually involving changes of state of the fluid.

**Relative humidity** – Ratio of the partial pressure of actual water vapour in the air as compared to the partial pressure of maximum amount of water that may be contained at its dry bulb temperature.

When the air is saturated, dry-bulb, wet-bulb and dewpoint temperatures are all equal, and the relative humidity is 100 percent.

**Return air** – The air that is collected from the conditioned space and returned to the conditioning equipment.

**Reverberation Time, \( T \)** – Time that would be required for the sound pressure level to decrease by 60 dB after the sound source has stopped.

**Note:** Reverberation time is usually measured in octave or third octave bands. It is not necessary to measure the decay over the full 60 dB range. The decay measured over the range 5 dB to 35 dB below the initial level is denoted by \( T_{30} \), and over the range 5 dB to 25 dB below the initial level by \( T_{20} \).

**Shade factor** – The ratio of instantaneous heat gain through the fenestration with shading device to that through the fenestration.

**Sick Building Syndrome (SBS)** – A term, which is used to describe the presence of acute non-specific symptoms in the majority of people caused by working in buildings with an adverse indoor environment. It could be a cluster of complex irritative symptoms like irritation of the eyes, blackened nose and throat, headaches, dizziness, lethargy, fatigue, irritation, wheezing, sinusitis, congestion, skin rash, sensory discomfort from odours, nausea, etc. These symptoms are usually short-lived and experienced immediately after exposure; and may disappear when one leaves the building.
SBS is suspected when significant number of people spending extended time in a building report or experience acute on-site discomfort. The economic consequences of SBS, like BRI, are decreased productivity, absenteeism and the legal implications if occupants IAQ complaints are left unresolved.

Sound – A vibrational disturbance, exciting bearing mechanisms, transmitted in predictable manner determined by the medium through which it propagates. To be audible the disturbance shall have to fall within the frequency range of 20 Hz to 20 000 Hz.

Sound Exposure Level, \( L_{AE} \) – Level of a sound, of 1 s duration, that has the same sound energy as the actual noise event considered.

Notes

1. The \( L_{AE} \) of a discrete noise event is given by the formula:

\[
L_{AE} = 10 \log_{10} \left\{ \frac{1}{t_o-t_1} \int_{t_1}^{t_o} \frac{P_A(t)^2}{P_o^2} \, dt \right\}
\]

Where

\[
P_A(t) = \text{is the instantaneous A-weighted sound pressure in pascals (Pa)};
\]

\[
t_2-t_1 = \text{is a stated time interval in seconds (s) long enough to encompass all significant sound energy of the event};
\]

\[
P_o = \text{is the reference sound pressure level (20\( \mu \)Pa); and}
\]

\[
t_o = \text{is the reference time interval (1 s).}
\]

2 \( L_{AE} \) is also known as \( L_{AX} \) (single-event noise exposure level).

Sound Power – The acoustic power of a sound source, expressed in Watts.

Sound Power Level, \( L_W \) – The acoustic power radiated from a given sound source as related to a reference power level (typically 10^{-12} watts) and expressed in decibels as:

\[
L_w = 10 \log \left\{ \frac{W}{10^{-12}} \right\}
\]

Where

\[
W = \text{Acoustic power in watts.}
\]

By definition, 1 W therefore corresponds to 120 dB for \( L_w \).

Sound Pressure, \( p \) – Root-mean-square value of the variation in air pressure measured in pascals (Pa), above and below atmospheric pressure, caused by the sound.

Sound Pressure Level, \( L_p \) – Quantity of sound pressure, in decibels (dB), given by the formula:

\[
L_p = 10 \log_{10} \left( \frac{p}{p_o} \right)^2
\]

Where

\[
P = \text{is the root mean square sound pressure in pascals (Pa); and}
\]

\[
P_o = \text{is the reference sound pressure (20\( \mu \)Pa)}.
\]

Note: The range of sound pressures for ordinary sounds is very wide. The use of decibels gives a smaller, more convenient range of numbers. For example, sound pressure levels ranging from 40 dB to 94 dB correspond to sound pressures ranging from 0.002 Pa to 1 Pa. A doubling of sound energy corresponds to an increase in level of 3 dB.

Sound Receiver – One or more observation points at which sound is evaluated or measured. The effect of sound on an individual receiver is usually evaluated by measurements near the ear or close to the body.

Sound Reduction Index, \( R \) – Laboratory measure of the sound insulating properties of a material or building element in a stated frequency band.

Note: For further information see Annex B.

Sound Source – Equipment or phenomena which generate sound. Sound room is the room containing sound source.

Spectrum – A quantity expressed as a function of frequency, such as sound pressure versus frequency curve.
Speech Interference Level (SIL) – A descriptor for rating steady noise according to its ability to interfere with conversation between two people. SIL is the arithmetic average of the sound pressure levels in the three octave bands with centre frequencies at 500, 1000 and 2000 Hz.

Smoke damper – A damper similar to fire damper, however, having provisions to close automatically on sensing presence of smoke in air distribution system or in conditioned space.

Static pressure – The pressure that is required to be created by the fan over the atmospheric pressure to overcome the system resistances such as resistances in ducts, elbows, filters, dampers, heating/cooling coils, etc.

Static pressure is measured by a U tube manometer relative to the atmospheric pressure, which is considered as zero pressure. In exhaust systems, fan produces negative static pressure which is again used to overcome the system resistances.

Standardized Impact Sound Pressure Level, $L_{int}$ – Impact sound pressure level normalized to a reverberation time in the receiving room of 0.5 s.

Note: Standardized impact sound pressure level is used to characterize the insulation of floors in buildings against impact sound in a stated frequency band (see Annex B).

Standardized Level Difference, $D_{int}$ – Difference in sound level between a pair of rooms, in a stated frequency band, normalized to a reverberation time of 0.5 s.

Note: Standardized level difference takes account of all sound transmission paths between the rooms (see Annex B).

Structure Borne Noise – Generation and propagation of time dependent motions and forces in solid materials which result in unwanted radiated sound.

Supply air – The air that has been passed through the conditioning apparatus and taken through the duct system and distributed in the conditioned space.

Supply and return air grilles and diffusers – Grilles and diffusers are the devices fixed in the air conditioned space for distribution of conditioned supply air and return of air collected form the conditioned space for recirculation.

Transient Sound – Sound which is audible for a limited period of time, for example sound from over flight of an airplane.

Thermal transmittance – Thermal transmission per unit time through unit area of the given building unit divided by the temperature difference between the air or some other fluid on either side of the building unit in ‘steady state’ conditions.

Thermal energy storage – Storage of thermal energy, sensible, latent or combination thereof for use in central system for air conditioning or refrigeration. It uses a primary source of refrigeration for cooling and storing thermal energy for reuse at peak demand or for backup as planned.

Third Octave Band – Band of frequencies in which the upper limit of the band is $2^{1/3}$ times the frequency of the lower limit.

Threshold of Hearing – The lowest continuous sound pressure level which will create an auditory sensation for the average human ear. Any sound below these levels will be inaudible and any sound above the threshold will vary in loudness dependent on intensity.

Vibration Isolation – Reduction of force or displacement transmitted by a vibratory source, often attained by use of a resilient mount.

Wavelength – The length in space of one complete cycle of a sound wave.

$$\lambda = \frac{(\text{Speed of sound})}{(\text{frequency})} = \frac{C}{f}$$

Water conditioning – the treatment of water circulating in a hydronic system, to make it suitable for air conditioning system due to its effect on the economics of air conditioning plant.

Untreated water used in air conditioning system may create problems such as scale formation, corrosion and organic growth. Appraisal of the water supply source including chemical analysis and determination of composition of dissolved solids is necessary to devise a proper water-conditioning programme.
Water hardness – Hardness in water represented by the sum of calcium and magnesium salts in water, which may also include aluminium, iron, manganese, zinc, etc. A chemical analysis of water sample should provide number of total dissolved solids (TDS) in a water sample in parts per million (ppm) as also composition of each of the salts in parts per million.

Temporary hardness is attributed to carbonates and bi-carbonates of calcium and/or magnesium expressed in parts per million (ppm) as CaCO$_3$. The remainder of the hardness is known as permanent hardness, which is due to sulphates, chloride, nitrates of calcium and/or magnesium expressed in ppm as CaCO$_3$.

Temporary hardness is primarily responsible for scale formation, which results in poor heat transfer resulting in increased cost of energy for refrigeration and air conditioning. Permanent hardness (non-carbonate) is not as serious a factor in water conditioning because it has a solubility which is approximately 70 times greater than the carbonate hardness. In many cases, water may contain as much as 1 200 ppm of non-carbonate hardness and not deposit a calcium sulfate scale.

The treated water where hardness as ppm of CaCO$_3$ is reduced to 50 ppm or below, is recommended for air conditioning applications.

pH is a measure of acidity, pH is a negative logarithm base 10, of the concentration of hydrogen ion in grams per litre. Water having a pH of 7.0 is neutral, a pH values less than 7 is acidic and pH value greater than 7 is alkaline. Water with pH less than 5 is quite acidic and corrosive to ordinary metals and needs to be treated.

Weighted Level Difference, $D_w$ – Single number quantity that characterizes airborne sound insulation between rooms but which is not adjusted to reference conditions.

Note: Weighted level difference is used to characterize the insulation between rooms in a building as they are: values cannot normally be compared with measurements made under other conditions (see good practice [8-4 (1)]).

Weighted Sound Reduction Index, $R_w$ – Single number quantity which characterizes the airborne sound insulating properties of a material or building element over a range of frequencies.

Note: The weighted sound reduction index is used to characterize the insulation of a material or product that has been measured in a laboratory (see Annex B).

Weighted Standardized Impact Sound Pressure Level, $L_{n,Tw}$ – Single number quantity used to characterize the impact sound insulation of floors over a range of frequencies.

Note: Weighted standardized impact sound pressure level is used to characterize the insulation of floors in buildings (see Annex B).

Weighted Standardized Level Difference, $D_{n,Tw}$ – Single-number quantity, which characterizes the airborne sound insulation between rooms.

Note: Weighted standardized level difference is used to characterize the insulation between rooms in a building (see Annex B).

Weighted Normalised Impact sound Pressure Level, $L_{n,w}$ – Single number quantity used to characterize the impact sound insulation of floors over a range of frequencies.

Note: Weighted normalized impact sound pressure level is usually used to characterize the insulation of floors tested in a laboratory (see Annex B).

White Noise – A noise whose spectrum (level) density is substantially independent of frequency over a specified range and has equal power for any range of frequencies of constant band width.

Wet-bulb temperature – The temperature registered by a thermometer whose bulb is covered by a wetted wick and exposed to a current of rapidly moving air of velocity not less than 4.5 m/s.

Wet-bulb temperature is indicated by a wet bulb psychrometer constructed and used according to specifications.

29.2 HEATING, VENTILATION AND AIR CONDITIONING

Planning design criteria
29.2.1 Fundamental requirements

29.2.1.1 The object of installing ventilation and air conditioning facilities in buildings shall be to provide conditions under which people can live in comfort, work safely and efficiently.

29.2.1.2 Ventilation and air conditioning installation shall aim at controlling and optimizing following factors in the building:

a) air purity and filtration;
b) air movement;
c) dry-bulb temperature;
d) relative humidity;
e) noise and vibration;
f) energy efficiency; and
g) fire safety.

29.2.1.3 All plans, specifications and data for air conditioning, heating and mechanical ventilation systems of all buildings and serving all occupancies within the scope of this Code shall be supplied to the Authority having jurisdiction, where called for.

29.2.1.4 The plans for air conditioning, heating and mechanical ventilation systems shall include all details and data necessary for review of installation such as:

a) building; name, type and location;
b) owner, name;
c) orientation: north direction on plans;
d) general plans: dimensions and height of all rooms;
e) intended use of all rooms;
f) detail or description of wall construction, including insulation and finish;
g) detail or description of roof, ceiling and floor construction, including insulation and finish;
h) detail or description of windows and outside doors, including sizes, weather stripping, storm sash, sills, storm doors, etc.,
i) internal equipment load, such as number of people, motor, heaters and lighting load;
j) layout showing the location, size and construction of the cooling tower (apparatus), ducts, distribution systems;
k) information regarding location, sizes and capacity of air distribution system, refrigeration and heating plant, air handling equipment;
l) information on air and water flow rates;
m) information regarding location and accessibility of shafts;
n) information regarding type and location of dampers used in air conditioning system;
o) chimney or gas vent size, shape and height;
p) location and grade of the required fire separations;
q) water softening arrangement; and
r) information on presence of any chemical fumes or gases.

29.2.2 Pre-planning

29.2.2.1 Design considerations

29.2.2.1.1 Cooling load estimates shall be carried out prior to installing air conditioning equipment. Calculation of cooling load shall take into account the following factors:

a) recommended indoor temperature and relative humidity;
b) outside design conditions as specified in 29.2.3.4.
c) details of construction and orientation of exposures like roof, floor, walls partition and ceiling;
d) fenestration area and shading factors
e) occupancy – number of people and their activity;
f) ventilation – requirement for fresh air;
g) Internal load – lighting and other heat generating sources like computers, equipment and machinery; and
h) hours of use.

29.2.2.1.2 The design of system and its associated controls shall also take into account the following:

a) nature of application;
b) type of construction of building;
c) permissible control limits;
d) control methods for minimizing use of primary energy;
e) opportunities for heat recovery;
f) energy efficiency;
g) filtration standard;
h) hours of use; 
  i) diversity factor; and 
  j) outdoor air quality.

29.2.2.1.3 The operation of system in the following conditions should be considered when assessing the complete design

  a) Heat season,  
  b) Rainy season,  
  c) Harmattan season,  
  d) Intermediate seasons,  
  e) Night, and 
  f) Weekends and holidays.

29.2.2.1.4 Consideration should be given to changes in building load and the system designed so that maximum operational efficiency is maintained.

29.2.2.1.5 Special applications like hospitals/operating theatres, computer rooms, clean rooms, laboratories, libraries, museums/art galleries, sound recording studios, shopping malls, etc. shall be handled differently.

29.2.2 Planning of equipment room for central air conditioning plant

29.2.2.1 In selecting the location for plant room, the aspects of efficiency, economy and good practice should be considered and wherever possible it shall be made contiguous with the building. This room shall be located as centrally as possible with respect to the area to be air conditioned and shall be free from obstructing columns.

In the case of large installations (500 TR and above), it is advisable to have a separate isolated equipment room where possible. The clear headroom below soffit of beam should be minimum of 4.5m for centrifugal plants and minimum of 3.6m for reciprocating and screw type plants.

29.2.2.2 The floors of the equipment rooms should be light coloured and finished smooth. For floor loading, the air conditioning engineer should be consulted.

29.2.2.3 Supporting of pipes within plant room spaces should be normally from the floor. However, outside plant room areas, structural provisions shall be made for supporting the water pipes from the floor/ceiling slabs. All floor and ceiling supports shall be isolated from the structure to prevent transmissions of vibrations.

29.2.2.4 Equipment rooms, wherever necessary, shall have provision for mechanical ventilation. In hot climate, evaporative air-cooling may also be considered.

29.2.2.5 Plant machinery in the plant room shall be placed on plain/reinforced cement concrete foundation and provided with anti-vibratory supports. All foundations should be protected from damage by providing epoxy coated angle nosing. Seismic restraints requirement may also be considered.

29.2.2.6 Equipment room should preferably be located adjacent to external wall to facilitate equipment movement and ventilation.

29.2.2.7 Wherever necessary, acoustic treatment should be provided in plant room space to prevent noise transmission to adjacent occupied areas.

29.2.2.8 Air conditioning plant room should preferably be located close to main electrical panel of the building in order to avoid large cable lengths.

29.2.2.9 In case air conditioning plant room is located in a basement, equipment movement route shall be planned to facilitate future replacement and maintenance. Service ramps or hatch in ground floor slab should be provided in such areas.

29.2.2.10 Floor drain channels or dedicated drain pipes laid in slope shall be provided within plant room space for effective disposal of waste water. Fresh water connection may also be provided in the air conditioning plant room.

29.2.2.11 Thermal energy storage

In case of a central plant, designed with thermal energy storage, its location shall be decided in consultation with the air conditioning engineer. The system may be located in a plant room, on rooftop, in open space near the plant room or buried in open space near the plant room.

For open area surface installation, horizontal or vertical system options shall be considered and approach ladders for manholes provided.
Buried installation shall take into account loads due to movement above, of vehicles, etc.

Provisions for adequate expansion tank and its connection to thermal storage tanks shall be made.

29.2.2.3 Planning equipment room for air handling units and package units

29.2.2.3.1 This shall be located as centrally as possible to the conditioned area and contiguous to the corridors or other spaces for carrying air ducts. For floor loading, the air conditioning engineer shall be consulted.

29.2.2.3.2 In the case of large and multistoried buildings, independent air handling unit should be provided for each floor. The area to be served by the air-handling unit should be decided depending upon the provision of fire protection measures adopted. Air handling unit rooms should preferably be located vertically one above the other.

29.2.2.3.3 Provision should be made for the entry of fresh air. The fresh air intake shall have louvers having rain protection profile, with volume control damper and bird screen.

29.2.2.3.4 In all cases air intakes shall be so located as to avoid contamination from exhaust outlets or to the sources in concentrations greater than normal in the locality in which the building is located.

29.2.2.3.5 Exterior openings for outdoor air intakes and exhaust outlets shall preferably be shielded from weather and insects.

29.2.2.3.6 No air from any dwelling unit shall be circulated directly or indirectly to any other dwelling unit, public corridor or public stairway.

29.2.2.3.7 All air handling rooms should preferably have floor drains and water supply. The trap in floor drain shall provide a water seal between the air conditioned space and the drain line.

29.2.2.3.8 Supply/return air duct shall not be taken through an emergency fire staircase. However, exception can be considered if fire isolation of ducts at wall crossings is carried out.

29.2.2.3.9 Waterproofing of air handling unit rooms shall be carried out to prevent damage to floor below.

29.2.2.3.10 The floor should be light coloured, smooth finished with terrazzo tiles or the equivalent. Suitable floor loading should also be provided after consulting with the air conditioning engineer.

29.2.2.3.11 Where necessary, structural design should avoid beam obstruction to the passage of supply and return air ducts. Adequate ceiling space should be made available outside the air handling unit room to permit installation of supply and return air ducts and fire dampers at air handling unit room wall crossings.

29.2.2.3.12 The air handling unit rooms may be acoustically treated, if located in close proximity to occupied areas.

29.2.2.3.13 Access door to air handling unit room shall be single/double leaf type, air tight, opening outwards and should have a sill to prevent flooding of adjacent occupied areas. It is desired that access doors in air conditioned spaces should be provided with tight sealing, gaskets and self closing devices for air conditioning to be effective.

29.2.2.3.14 It should be possible to isolate the air handling unit room in case of fire. The door shall be fire resistant and fire/smoke dampers shall be provided in supply/return air duct at air handling unit room wall crossings and the annular space between the duct and the wall should be fire-sealed using appropriate fire resistance rated material.

29.2.2.3.15 For buildings with large structural glazing areas, care should be taken for providing fresh air intakes in air handling unit rooms. Fire isolation shall be provided for vertical fresh air duct, connecting several air handling units.

29.2.2.4 Planning of pipe shafts

29.2.2.4.1 The shafts carrying chilled water pipes should be located adjacent to air handling unit room or within the room.

29.2.2.4.2 Shaft carrying condensing water pipes to cooling towers located on terrace should be vertically aligned.
29.2.2.4.3 All shafts shall be provided with fire barrier at floor crossings.

29.2.2.4.4 Access to shaft shall be provided at every floor.

29.2.2.5 Planning for supply air ducts and return air.

29.2.2.5.1 Duct supports, preferably in the form of angles of mild steel supported using stud anchors shall be provided on the ceiling slab from the drilled hole. Alternately, duct supports may be fixed with internally threaded anchor fasteners and threaded rods without damaging the slabs or structural members.

29.2.2.5.2 If false ceiling is provided, the support for the duct and the false ceiling, shall be independent. Collars for grilles and diffusers shall be taken out only after false ceiling/boxing framework is done and frames for fixing grilles and diffusers have been installed.

29.2.2.5.3 Where a duct penetrates a masonry wall it shall either be suitably covered on the outside to isolate it from the masonry, or an air gap shall be left around it to prevent vibration transmission. Further, where a duct passes through a fire resisting compartment/barrier, the annular space shall be sealed with fire sealant to prevent smoke transmission.

29.2.2.6 Cooling tower

29.2.2.6.1 Cooling towers are used to dissipate heat from water cooled refrigeration, air conditioning and industrial process systems. Cooling is achieved by evaporating a small proportion of re-circulating water into an outdoor air stream. Cooling towers are installed at a place where free flow of atmospheric air is available.

29.2.2.6.2 Range of a cooling tower is defined as the temperature difference between the entering and leaving water. Approach of the cooling tower is the difference between leaving water temperature and the entering air wet bulb temperature.

29.2.2.6.3 Types of cooling tower

29.2.2.6.3.1 Natural draft

This type of tower is larger than a mechanical draft tower as it relies on natural convention to obtain the air circulation. A natural draft tower needs to be tall to obtain the maximum chimney effect or rely on the natural wind currents.

29.2.2.6.3.2 Mechanical draft

The fans on mechanical draft towers may be on the inlet air side (forced draft) or exit air side (induced draft). Typically, these have centrifugal or propeller type fans, depending on the pressure drop in the tower, permissible sound levels and energy usage requirement. On the basis of direction of air and water flow, mechanical draft cooling towers can be counter flow or cross flow types.

29.2.2.6.4 Factors to be considered for cooling tower selection are:

a) Design wet-bulb temperature and approach of cooling tower.
b) Height limitation and aesthetic requirement.
c) Location of cooling tower, considering the possibility of easy drain back from the system.
d) Placement with regard to adjacent walls and windows, other buildings and effects of any water carried over by the air stream.
e) Noise levels, particularly during silent hours, and vibration control.
f) Material of construction for the tower.
g) Direction and flow of wind.
h) Quality of water used for make-up.
i) Maintenance and service space.
j) Ambient air quality.

29.2.2.6.5 The recommended floor area requirement for various types of cooling towers are as given below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Floor Area Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural draft cooling tower</td>
<td>0.15 to 0.20 m²/t of refrigeration</td>
</tr>
<tr>
<td>Induced draft cooling tower</td>
<td>0.10 to 0.13 m²/t of refrigeration</td>
</tr>
<tr>
<td>Fibre-reinforced plastic</td>
<td>0.07 to 0.08 m²/t of refrigeration</td>
</tr>
</tbody>
</table>

29.2.2.6.6 Any obstruction to free of air to the cooling tower shall be avoided.

29.2.2.6.7 Structural provision for the cooling tower shall be taken into account while designing the building. Vibration isolation shall be an important consideration in the structural design.
29.2.2.6.8 Special design requirements are necessary where noise to adjoining buildings is to be avoided.

29.2.2.6.9 As given below, certain amount of water is lost from circulating water in the cooling tower:

   a) Evaporation loss – In a cooling tower, the water is cooled by evaporating a part of the circulating water into the air stream. The amount of circulating water so evaporated is called ‘evaporation loss’. Usually it is about 1 percent of the rate of water circulation.

   b) Drift loss - A small part of circulating water is lost from the cooling tower as liquid droplets entrained in the exhaust air stream. Usually the drift loss is 0.1 percent to 0.2 percent of rate of water circulation.

   c) Blow-down/bleed-off – To avoid concentration of impurities contained in the water beyond a certain limit, a small percentage of water in the cooling water system is often purposely drained off or discarded. Such a treatment is called ‘blow-down’ or ‘bleed off’. The amount of blow-down is usually 0.8 percent to 1 percent of the total water circulation.

If simple blow-down is inadequate to control scale formation, chemicals may be added to inhibit corrosion and limit microbiological growth.

Provision shall be made to make-up for the loss of circulating water.

29.2.2.6.10 Provision for make-up water tank to the cooling tower shall be made. Make-up water tank to the cooling tower shall be separate from the tank serving drinking water.

29.2.2.6.11 Make-up water having contaminants or hardness, which can adversely affect the refrigeration plant life, shall be treated.

29.2.2.6.12 Cooling tower should be so located as to eliminate nuisance from drift to adjoining structures.

29.2.2.7 Glazing

29.2.2.7.1 Glazing contributes significantly to heat addition in airconditioned space; measures shall, therefore, be adopted to minimize the gain.

29.2.2.7.2 While considering orientation of the building, glazing in walls subjected to heavy sun exposure shall be avoided. In case it is not possible to do so, double glazing or heat resistant glass should be used. Glazing tilted inward at about 12° also helps curtail transmission of direct solar radiation through the glazing.

29.2.2.7.3 Where sun breakers are used, the following aspects shall be kept in view:

   a) The sun breakers shall shade the maximum glazed area possible, specially from the altitude and azimuth angle of the sun, which is likely to govern the heat load;

   b) The sun breakers shall preferably be light and bright in colour so as to reflect back as much of the sunlight as possible.

   c) The sun breakers shall preferably be 1m away from the wall face, with free ventilation, particularly from top to bottom, and are meant for carrying away the heat which is likely to get boxed between the sun breakers and the main building face.

   d) The sun breakers shall be installed as to have minimum conduction of heat from sun breakers to the main building.

29.2.2.7.4 Where resort is taken to provide reflecting surfaces for keeping out the heat load, care should be taken regarding the hazards to the traffic and people on the road from the reflected light from the surfaces.

29.2.2.7.5 Day light transmittance for various type of glass is given in Table 1.

<table>
<thead>
<tr>
<th>Type of glass</th>
<th>Visible Transmittance W/(m²°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) 3mm regular sheet or plate glass</td>
<td>0.86 to 0.91</td>
</tr>
<tr>
<td>ii) 3mm grey sheet glass</td>
<td>0.31 to 0.71</td>
</tr>
<tr>
<td>iii) 5mm grey sheet glass</td>
<td>0.61</td>
</tr>
<tr>
<td>iv) 5.5mm grey sheet</td>
<td>0.14 to 0.56</td>
</tr>
</tbody>
</table>
29.2.2.8 Roof insulation

29.2.2.8.1 Under-deck or over-deck insulation shall be provided for exposed roof surfaces using suitable insulating materials. Over-deck insulation should be properly waterproofed to prevent loss of insulating properties.

29.2.2.8.2 The overall thermal transmittance from the exposed roof should be kept as minimum as possible and under normal conditions, the desirable value should not exceed 0.58 W/(m²°C).

29.2.2.8.3 The ceilings of floors which are not to be air conditioned may be suitably insulated to give an overall thermal transmittance not exceeding 1.16 W/(m²°C).

29.2.3 AIR CONDITIONING

Design of air conditioning

29.2.3.1 General

A ventilation and air conditioning system installed in a building should clean, freshen and condition the air within the space to be air conditioned. This can be achieved by providing the required amount of fresh air either to remove totally or to dilute odours, fumes, etc (for example, from smoking). Local extract systems may be necessary to remove polluted air from kitchens, toilets, etc. Special air filters may be required to remove contaminants or smells when air is re-circulated.

It is desirable that access doors to air conditioned space are provided with tight sealing gaskets and self closing devices for air conditioning to be effective.

Positions of air inlets and extracts to the system are most important and care should be taken in their location. Consideration should be given to relatively nearby buildings and any contaminated discharges from those buildings. Inlets should not be positioned near any flue outlets, dry cleaning or washing machine extraction outlets, kitchen, water-closets, etc. When possible, air inlets should be at high level so as to induce air from as clean an area as possible. If low level intakes are used, care should be taken to position them well away from roadways and car parks.

29.2.3.2 Design considerations

29.2.3.2.1 Types of systems

Systems for air conditioning need to control temperature and humidity within predetermined limits throughout the year. Various types of refrigerating systems are available to accomplish the tasks of cooling and dehumidifying, which are an essential feature of air conditioning. Systems for air conditioning may be grouped as all-air type, air and water type, wall water type or unitary type.

29.2.3.2.1.1 All-air system

This type of air conditioning system provides complete sensible and latent cooling, preheating and humidification in the air supplied by the system. Most plants operate on the re-circulation principle, where a percentage of the air is extracted and the remainder mixed with incoming fresh air.

Low velocity systems may be used. High velocity systems although require smaller ducts, are high on fan energy, require careful acoustic treatment and higher standards of duct construction.

29.2.3.2.1.1.1 Constant volume system

Accurate temperature control is possible, according to the system adopted. Low velocity system variations include dehumidification with return air bypass, and multi-zone (hot deck/cold deck mixing). High velocity system may be single or dual duct type.

29.2.3.2.1.2 Variable volume system

Most Ghanaian air conditioning systems operate at partial load for most of the year and the variable air volume (VAV) system is able to
reduce energy consumption by reducing the supply air volume to the space under low load conditions. The VAV system can be applied to interior or perimeter zones, with common or separate fans, with common or separate air temperature control. The greatest energy saving associated with VAV occurs at the perimeter zones, where variation in solar and outside temperature allow the supply air quantity to be reduced. Good temperature control is possible but care should be taken at partial load to ensure adequate fresh air supply and satisfactory control of air distribution and space humidity.

**29.2.3.2.1.2 Air and water system**

Control of conditions within the space is achieved by initial control of the supply air from a central plant but with main and final control at a terminal unit within the conditioned space. The supply air provides the necessary ventilation air and the small part of the total conditioning. The major part of room load is balanced by water through a coil in the terminal unit, which can be either a fan coil unit or an induction unit.

Depending on the degree of control required, the water circulating system can be of two, three or four pipe arrangement. With two pipe circulation a single flow and a single return circulated chilled or hot water as required. Such a system can only provide heating or cooling to the system on a changeover basis, so it is ineffective where wide modulations of conditions over short periods are required. The installed cost however is naturally the lowest of all the circulation systems. The three pipe system is a way of overcoming the disadvantages of the two pipe system without raising the installed cost too high. In this system a separate hot water flow and chilled water flow is taken to the terminal units but a common return is taken from these units to the plant room. The best system from a control point of view is the four pipe system, where separate hot water and chilled water supply and returns are taken from the plant room to the terminal units. Although the most expensive method of circulating the water, it is the only satisfactory one, if reasonable control is required throughout the year.

**29.2.3.2.1.3 All water system**

In the simplest layout, the fan coil units may be located against an outside wall with a direct, fresh air connection. A superior arrangement utilizes a ducted, conditioned, fresh air supply combined with mechanical extract ventilation.

Control of unit output may be achieve by fan speed and water flow/temperature control. Electric power is required at each terminal unit.

Provision of variable volume water flow system for chilled water circulation is recommended for varying load conditions. This may be incorporated with the help of constant volume primary chilled water circuit and variable flow secondary chilled water circuit having pumps with variable speed drives and pressure sensor to control the speed. This system allows better control on energy consumption under partial load conditions due to diversity or seasonal load variations.

**29.2.3.2.1.4 Unitary systems**

Such systems are usually those incorporating one or more units or packaged air conditioners having a direct expansion vapour compression refrigeration system. Similar units using chilled water from a central plant would be designated fan coil systems. Most units are only suitable for comfort applications but specially designed units are also available for process and industrial applications.

**29.2.3.2.2 Vapour compression water chiller**

These normally contain the complete refrigerating system, comprising the compressor, condenser, expansion device and evaporator together with the automatic control panel. The unit can be set down on to a solid foundation on resilient mountings. Pipe connection require flexible couplings; these should be considered in conjunction with the design of the pump mountings and the pipe supports.

Capacity control is normally arranged to maintain an approximately constant temperature of the chilled water leaving the evaporator. This may be adequate for one or two packages, but a more elaborate central control system may be necessary for a large number. The design of the refrigeration control system should be integrated, or be compatible, with the control system for the heat transfer medium circulated to the air cooler.

It is normal for installation to have several water chilling packages, both to provide for
standby and enable the cooling load to be matched with the minimum consumption of power. Although most packages can reduce capacity to match the cooling demand, the consumption of the power per unit of cooling increases, the resulting drop in efficiency is most serious when below one-third capacity.

Power consumption can be reduced by taking advantage of a fall in the ambient temperature, which permits a corresponding fall in the condensing temperature and consequent reduction in the compressor power. It is important, for economy in the operation, that the optimum equipment selection and design of the control system is achieved.

The classification of the water chilling packages is by the type of compressor.

29.2.3.2.2.1 Centrifugal compressors

These compressors have an impeller that imparts to the refrigerant vapour, a high kinetic energy, which is then transformed into pressure energy. For water chilling applications, compressors with one or two stage of compression are used. Two stage units often incorporate an interstate economizer for improving efficiency.

The compressor can be modulated down to approaching 10 percent of full load capacity, with some control of the condensing pressure. Because of the nature of compression process, the flow through the compressor can become unstable if the compressor is called upon to produce a pressure rise in excess of its design limits. This phenomenon, known as surging, is a serious problem but occurs only under a fault condition. Typical faults are excessive fouling of the condenser, a partial failure of the condenser coolant flow or an accumulation of a non-condensable gas (air) in the condenser. Unchecked surging can lead to damage to the compressor or its drive and does increase the noise level.

The use of low pressure refrigeration to suit the characteristics of the compressor in the smaller size range, means that the evaporator operates at below atmospheric pressure, thus a leak can draw in air and atmospheric moisture. These should be prevented from accumulating, since these interfere with the operation of the plant and cause corrosion.

The compressors may be driven either directly by electric motor or via a speed-increasing gear train. Units are available in ‘open’ form, that is, compressor and motor are separate items, or in semi-hermetic form where the motor and compressor are contained in a common pressure-tight casing that is bolted together. The latter type eliminates the drive shaft gland seal (a potential point of leakage), which is necessary on the former.

The centrifugal compressor type water chilling packages normally include a shell-and-tube water cooled condenser and a flooded shell-and-tube evaporator, but units are also available incorporating an air cooled condenser. The expansion device is commonly an electric expansion valve or high pressure float regulating valve.

29.2.3.2.2.2 Screw compressors

Two types of screw compressors are available, that is, single and twin screw, and both are positive displacement machines. Compression of the refrigerant vapour is achieved by the progressive reduction of the volume contained within the helical flutes of the cylindrical rotor(s) as they rotate.

Oil is injected into the rotor chamber for sealing and lubrication purposes and is removed from the refrigerant discharge gas in an oil separator before the refrigerant passes on to the condenser. No oil separator is 100 percent efficient and so a small quantity of oil always passes through with the refrigerant. On systems using a direct expansion evaporator, the oil is trapped in the evaporator and an oil recovery system is necessary.

With some systems an oil cooler is required in the oil circulation system, to remove the heat gathered by the oil during compression cycle. On other systems liquid refrigerant is injected into the compressor to remove the heat of compression instead of using the conventional oil cooler. Such an arrangement can impose a small penalty on the plant capacity.

The condenser most commonly used on packaged units is the water cooled shell-and-tube type, but equipment with air cooled condensers is also available. The expansion device used will depend on the evaporator type but it is often an electronic expansion valve (single or in multiple) of conventional or modified form.
Screw compressors are available in open and semi-hermetic form (see clause 29.2.3.2.2.1) and are generally coupled direct to two-pole motors. The capacity of the compressor can be modulated down to 10 percent of full load capacity.

29.2.3.2.2.3 Reciprocating compressors

These are available in a wide range of sizes and designs. They are almost invariably used in packages up to 120 TR cooling capacity.

Because the cylinders have automatic valves, a single compressor may be used over wide range of operating conditions with near optimum efficiency, whereas other types of compressors require detailed modification to give optimum efficiency at different conditions. This is, however, of minor importance for normal air conditioning duties.

Capacity control is achieved by making cylinders in-operative, usually propping open the suction valves, thus, capacity reduction is in a series of steps rather than by modulation. Typically, a four-cylinder compressor would be unloaded in four steps. It is therefore necessary to allow for this stepwise operation in designing the chilled water temperature control system.

The evaporator is normally of the dry expansion type, to permit oil from the compressor to circulate round the system with the refrigerant. Shell-and-tube water cooled condensers are common, but any type of condenser can be used. With air cooled condensers it is normal practice to build the machine package so that it may be located on the roof in a package including the condenser.

It is common for the electric drive motors to be built into the compressor assembly; this is known as a ‘semi-hermetic’ drive to distinguish it from the ‘hermetic’, in which the compressor and motor are enclosed within a pressure vessel and cannot therefore be serviced.

The semi-hermetic compressor is more compact and is quieter in operation than the ‘open’ drive compressor, but involves a more difficult service operation in the event of a motor failure. It gains in reliability, however, by avoiding the shaft seal of the ‘open’ compressor.

It is recommended that a multiple hermetic or semi-hermetic compressor unit should not be connected to a common refrigerant system, as failure of one motor can precipitate failure of the others. Separate refrigerant circuits for each compressor should be used.

29.2.3.2.3 Absorption system

The absorption cycle uses a solution that by absorbing the refrigerant replaces the function of the compressor. The absorbent/refrigerant mixture is then pumped to a higher pressure where the refrigerant is boiled off by the application of heat, to be condensed in the condenser.

Absorption machines are mostly used in liquid-chilling applications. These are most suitable for hotels and hospitals where steam is readily available from the boilers.

29.2.3.2.3.1 Indirect firing

The lithium bromide/water absorption system can be powered by medium or high temperature hot water and low or medium pressure steam. Water is the refrigerant and the lithium bromide the absorbent. The four compartments enclosing the heat exchanger tube bundles for the condenser, evaporator, generator and absorber can be a single or multiple pressure vessel arrangement. The whole assembly has to be maintained under a higher vacuum, which is essential for the correct functioning of the unit. Water and absorbent solutions are circulated within the unit by electricity driven pumps.

Capacity control down to 10 percent of full load capacity is achieved by modulating the flow of the heating medium in relation to the cooling demand. There is some loss in performance at part load, which can be compensated by refinements in the system design and control.

29.2.3.2.3.2 Direct firing

Direct fired lithium bromide/water absorption plants have become common, by incorporating precise control of generator temperature necessary to avoid crystallization.

Ammonia/water systems can be and are direct fired, but are rarely used for water chilling duties except for small sized units, which are installed outside the building. There are two reasons for this, firstly capital costs are higher and secondly the danger to personnel in the event of leakage of the refrigerant.

Direct firing has the advantage that the losses in an indirect heating system are avoided, but
in an air conditioning installation where a boiler system is installed to provide heating, the advantage is minimal.

29.2.3.3 System design

29.2.3.3.1 Ductwork and air distribution

29.2.3.3.1.1 Materials

Ductwork is normally fabricated, erected and finished to the requirements in accordance with accepted standards. Designers should specify the requirements as appropriate for the velocity and pressure, and materials to be employed. Ductwork is generally manufactured from galvanized steel sheet. Ductwork may also be manufactured from aluminium sheet for applications like operation theatres and intensive care units where stringent cleanliness standards are a functional requirement. Galvanised steel sheets shall be in accordance with the accepted standard. Where building materials, such as concrete or brick, are used in the formation of airways, the interior surface should be fire resistant, smooth, airtight and not liable to erosion.

29.2.3.3.1.2 Ductwork design

Design calculation made to determine the size and configuration of ductwork in respect of pressure drop and noise generation should conform to standard methods.

Ductwork design should also take into account the recommendations for fire protection (see Part 3 Use and Occupancy Classification of the Ghana Building Code) relating to the design of air handling system to fire and smoke control in buildings.

29.2.3.3.1.3 Layout consideration

When designing ductwork, consideration should be given to:

- Co-ordination with building, architectural and structural requirements;
- Co-ordination with other services;
- Simplifying installation work;
- Providing facilities and access for commissioning and testing;
- Providing facilitating and access for operating and maintenance;
- Meeting fire and smoke control requirement; and
- Prevention of vibration and noise transmission to the building/space.

29.2.3.3.2 Piping and water distribution system

29.2.3.3.2.1 Materials

Steel piping with welded or flanged joints is commonly used. Flanges for flanged joints are welded to pipes. The choice of materials or any installation will be governed by economic considerations, but care should be taken to minimize the possibility of corrosion when choosing material combinations.

29.2.3.3.2.2 Design principles

The system design should achieve the following two main objectives:

- A good distribution of water to the various heat exchangers/cooling coils at all conditions of load. This will be influenced by the method chosen to control the heat transfer capacity of air handling units. Failure to achieve good hydraulic design may lead to difficulties with system balancing. Adequate provision should be made for measuring flow rates and pressure differentials.
- An economic balance between pipe size and piping cost.

Excessive water velocities should be avoided, as they may lead to noise at pipe junctions and bends.

When multiple water-chilling packages have to be used in a large system, the control of the machines and the arrangement of the water circulation should be considered as an integrated whole. It is not possible to obtain satisfactory result by considering control and system design separately.

Temperature changes in the system lead to changes in the volume of water, which has to be allowed to expand into a suitable expansion tank. It is essential that the point at which the expansion tank is connected into the system be such that it is never shutoff. It is normal practice to locate the expansion tank above the highest point in the system, so that a positive pressure is maintained when all the pumps are stopped. If this is not possible, a
closed tank can be installed at a lower level and pressurized by an inert gas. A Closed expansion tank with an air separator in the chilled water system helps in improving the life and efficiency of chilled water piping and heat exchange equipment.

For central chilled water air conditioning systems, water is the usual heat transfer medium used to convey the heat from the air-handling units to the primary refrigerant in the evaporator. In certain special cases, when temperatures lower than 5°C are required, an anti-freeze such as ethylene glycol may be added to depress the freezing point.

29.2.3.2.3 Piping design

The arrangement of the water piping will depend upon the cooling or heating systems chosen as being the most suitable for the building.

The water velocities normally used are dependent on pipe size but are usually in the range 1 m/s to 3 m/s.

Main headers in the plant room are designed for very low velocity around 1 m/s. Noise can be caused by velocities in excess of 4 m/s but this is more likely to be caused by air left in the pipes by inadequate venting. Where materials other than steel are used, erosion can occur at the higher velocities particularly if the water is allowed to become acidic.

Friction factor in piping should not exceed 5m of water for 100m of pipe length. The power consumed in circulating the water around the system is proportional to the pressure loss (due to friction) and the flow. It is therefore an advantage to design a system with a water temperature rise say 5°C to 7°C which results in minimizing the flow rate.

Air-conditioning systems operate for a large part of the time at less than the design load, and this means that operating costs can be minimized if the water quantity circulated can be reduced at partial load. This should be done with variable speed pumping systems.

29.2.3.2.4 Layout considerations

The layout of the main pipe runs should be considered in relation to the building structure, which will have to support their weight and carry the imposed axial loads. The positioning of expansion joints should be considered in relation to the branches, which may only accommodate small movements. The pumps should not be subjected to excessive loads from the piping.

Provision should be made for venting air and any gas formed by corrosion processes from the high points in the system; failure to do this can lead to restricted water flows and poor performance.

New systems invariably contain debris of one sort or another left during construction, and this can cause trouble by blocking pipes, control valves and pumps if it is not removed during testing and commissioning. Piping system should be designed to permit proper cleaning and flushing and should include suitable strainers at appropriate locations.

29.2.3.3 Thermal insulation

29.2.3.3.1 Air conditioning and water distribution systems carry chilled or heated fluids. Thermal insulation is required to prevent undue heat gain or loss and also to prevent internal and external condensation; a vapour seal is essential if there is a possibility of condensation within the insulating materials.

29.2.3.3.2 The selection of suitable thermal insulating materials requires that consideration be given to physical characteristics as follows:

a) Fire properties – Certain insulating materials are combustible or may, in a fire, produce appreciable quantities of smoke and noxious and toxic fumes.

b) Materials and their finishes should inherently be proof against rotting, mould and fungal growth, and attack by vermin, and should be non-hygroscopic.

c) Material should not give rise to objectionable odour at the temperature at which they are to be used.

d) The material should not cause a known hazard to health during application, while in use, or on removal, either from particulate matter or from toxic fumes.

988
e) It should have a low thermal conductivity throughout the entire working temperature range.

f) It should be non-flammable and should not support nor spread fire.

g) It should have good mechanical strength and rigidity otherwise it would have to be clad for protection.

29.2.3.4 Design conditions

29.2.3.4.1 Temperature

29.2.3.4.1.1 General consideration

Certain minimum temperatures may be required depending on the type of application and by local regulations. Maximum permitted cooling temperatures may be stipulated by relating to energy conservation.

From the comfort aspect, it is important to take into account the effect of radiant temperature in fixing the desire air temperatures to maintain comfortable conditions.

When large windows/curtain walls are used, it may be necessary to provide shading/north orientation to protect the occupants form solar radiation and to reduce the cooling load on the system. It is not practical to fully compensate for solar heating, owing to its intermittent nature, simply by lowering air temperature.

A person’s heat loss, and hence his feeling of comfort, depends not only on the air temperature but also on the radiant heat gain, the air movement and the humidity of the air. Many attempts have been made to devise a single index that combines the effect of two or more of these separate variables. In practice the difference between these indices is small, provided the various parameters do not vary beyond certain limits.

29.2.3.4.1.2 Design temperatures

It should be noted that, although comfort conditions are established in terms of resultant temperature, the design air temperature of air conditioning should be as specified in this Clause in terms of dry-bulb temperature and relative humidity or wet-bulb temperature.

29.2.3.4.2 Humidity

29.2.3.4.2.1 Comfort considerations

The controlled temperature levels should also be considered in relation to the humidity of the air. A high humidity reduces evaporative cooling from the body and hence creates the sensation of a higher temperature. Beyond certain limits however, humidity produces disagreeable sensations.

For normal comfort conditions, relative humidity (RH) values between 40 percent and 70 percent are acceptable.

29.2.3.4.3 Inside design conditions

The inside design conditions for some of the applications are indicated in Table 2.

29.2.3.4.4 Outside design conditions

Values of ambient dry-bulb and wet-bulb temperatures against the various annual percentiles represent the value that is exceeded on average by the indicated percentage of the total number of hours. The 0.4 percent, 1.0 percent and 2.0 percent values are exceeded on average 35, 88 and 175 h respectively in a year. The 99.0 percent and 99.6 percent values are defined in the same way but are usually reckoned as the values for which the corresponding weather elements are less than the design conditions for 88h and 35h, respectively.

Mean coincidental values are the average of the indicated weather element occurring concurrently with the corresponding design value.

After the calculation of design dry-bulb temperatures and the programme located the values of corresponding wet-bulb temperatures from the database for that particular station, the average of these values were computed, which were then called mean of coincidental wet-bulb temperature.
<table>
<thead>
<tr>
<th>Category</th>
<th>Inside Design Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat season (3)</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>i) Restaurants</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 55 to 60%</td>
</tr>
<tr>
<td>ii) Office buildings</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 50 to 60%</td>
</tr>
<tr>
<td>iii) Radio and television studios</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 45 to 55%</td>
</tr>
<tr>
<td>iv) Departmental stores</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 50 to 60%</td>
</tr>
<tr>
<td>v) Hotel guest rooms</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 50 to 60%</td>
</tr>
<tr>
<td>vi) Class rooms</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 50 to 60%</td>
</tr>
<tr>
<td>vii) Auditoriums</td>
<td>DB 23 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 50 to 60%</td>
</tr>
<tr>
<td>viii) Recovery rooms</td>
<td>DB 24 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 45 to 55%</td>
</tr>
<tr>
<td>ix) Patient rooms</td>
<td>DB 24 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 45 to 55%</td>
</tr>
<tr>
<td>x) Operation theatres</td>
<td>DB 17 to 27°C</td>
</tr>
<tr>
<td></td>
<td>RH 45 to 55%</td>
</tr>
<tr>
<td>xi) Museums and libraries</td>
<td>DB 20 to 22°C</td>
</tr>
<tr>
<td></td>
<td>RH 40 to 55%</td>
</tr>
<tr>
<td>xii) Telephone terminal rooms</td>
<td>DB 22 to 26°C</td>
</tr>
<tr>
<td></td>
<td>RH 40 to 50%</td>
</tr>
</tbody>
</table>
In the same way design wet-bulb temperatures and coincidental dry-bulb temperatures were evaluated.

Selection: The design values of 0.4 percent, 1.0 percent and 2.0 percent annual cumulative frequency of occurrence may be selected depending upon application of air conditioning system.

For normal comfort jobs values under 1 percent column could be used for cooling loads and 99 percent column for heating loads. For critical applications values under 0.4 percent column could be used for cooling loads and 99.6 percent column for heating loads.

For critical jobs and high energy consumption applications, hourly load analysis should be evaluated using computer programmes.

For industrial and other specific applications, the design conditions shall be as per user’s requirement.

Adequate movement of air shall always be provided in an air conditioned enclosure, but velocities in excess of 0.5 m/s in the zone between floor level and 1.5 m level shall generally be avoided; in the case of comfort air conditioning, recommended air velocity in this zone is 0.13 m/s to 0.23 m/s, except in the vicinity of a supply or return air grille.

### 29.2.3.4.5 Minimum outside fresh air

Fresh air supply is required to maintain an acceptably non-odourous atmosphere (by diluting body odours and tobacco smoke) and to dilute the carbon dioxide exhaled. This quantity may be quoted per person and is related to the occupant density and activity within the space. Table 3 gives minimum fresh air supply rates for mechanically ventilated or air conditioned space. The quantity and distribution of introduced fresh air should take into account the natural infiltration of the building.

Table 3 specifies requirements for ventilation air quantities for 100 percent outdoor air when the outdoor air quality meets the specifications for acceptable outdoor air quality. While these quantities are for 100 percent outdoor air, they also set the amount of air required to dilute contaminants to acceptable levels. Therefore, it is necessary that at least this amount of air be delivered to the conditioned space at all times the building is in use.

The proportion of fresh air introduced into a building may be varied to achieve economical operation. When the fresh air can provide a useful cooling effect, the quantity shall be controlled to balance the cooling demand. However, when the air is too warm or humid the quantity may be reduced to a minimum to reduce the cooling load.

For transfer of heat/moisture, air circulation is required to transfer the heat and humidity generated within the building. In simple systems the heat generated by the occupants, lighting, solar heat and heat from electrical and mechanical equipment may be removed by the introduction and extraction of large quantities of fresh air. In more elaborate systems air may be re-circulated through conditioning equipment to maintain the desired temperature and humidity. The air circulation rates are decided in relation to the thermal or moisture loads and the practical cooling range of the air.

### 29.2.3.4.6 Air movement

#### a) In air conditioned spaces

- Air movements is desirable, as it contributes a feeling of freshness, although excessive movement should be avoided as this leads to complaints of draughts. The speed of an air current becomes more noticeable as the air temperature falls, owing to its increased cooling effect. The design of the air distribution system therefore has a controlling effect of the quantity and temperature of the air that may be introduced into a space. The quantity of fresh air should not be increased solely to create air movement; this should be effected by air re-circulation within the space or by inducing air movement with the ventilation air system.

#### b) In buildings

- Air flow within a building should be controlled to minimize transfer of fumes and smells, for example from kitchens to restaurants and the like. This is achieved by
creating air pressure gradients within the building, by varying the balance between the fans introducing fresh air and those extracting the stale air. For example, the pressure should be reduced in a kitchen below that of the adjacent restaurant.

Care should be taken, however, to avoid excessive pressure differences that may cause difficulty in opening doors or cause them to slam. In other cases, such as computer rooms, the area may be pressurized to minimize the introduction of dust form adjacent areas.

29.2.3.4.6.1 Fire and smoke control

Air circulation system may be designed to extract smoke in event of a fire, to assist in the fire fighting operation and to introduce fresh air to pressurize escape routes.

29.2.3.4.6.2 Removal of particulate matter from air

Efficient air filtration prevents fouling of the system and is of special importance in urban areas, where damage is likely to be caused to decorations and fittings by discolouration owing to airborne dust particles. In order to obtain maximum filtration efficiency within the minimum capital and maintenance expenditure, the utmost care should be given to the location of the air intake in relation to the prevailing wind, the position of chimneys and the relative atmospheric dust concentration in the environs of the building. The recommendation for siting of air inlets given in Clause 29.2.3.1 should also be taken into account. Air filtration equipment should be regularly serviced.

Air borne dust and dirt may be generated within the building, from the interior finishes such as partitions, laminations, carpets, upholstery, etc., personnel and their movements as well as by machines such as, printers and fax machines

### Table 3 – Outdoor air requirements for ventilation of air conditioned areas and commercial facilities (Clause 29.2.3.4.5)

<table>
<thead>
<tr>
<th>Application</th>
<th>Estimated Maximum $^2$ Occupancy</th>
<th>Outdoor Air Requirement</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3) persons/1000 $^2$</td>
</tr>
<tr>
<td>i) Commercial dry cleaner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Food and Beverage Service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dining rooms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cafeteria, fast food</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bars, cocktail lounges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Supplementary smoke removal equipment may be required.

Make up air for food exhaust may require more ventilating air. The sum of the outdoor air and transfer air of acceptable quality from adjacent spaces shall be sufficient to provide an exhaust rate of not
iii) **Hotels, Motels, Resorts, Dormitories**

<table>
<thead>
<tr>
<th></th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bedrooms</strong></td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Living rooms</strong></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baths</strong></td>
<td></td>
<td></td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><strong>Lobbies</strong></td>
<td>30</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conference rooms</strong></td>
<td>50</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Assemble rooms</strong></td>
<td>120</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dormitory sleeping areas</strong></td>
<td>20</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Independent of room size

Installed capacity for intermittent use

See also food and beverage services, merchandising, barber and beauty shops, garages, offices. Some office equipment may require local exhaust.

iv) **Public spaces**

<table>
<thead>
<tr>
<th></th>
<th>(3)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Office space</strong></td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td><strong>Reception areas</strong></td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td><strong>Telecommunication centers and data entry areas</strong></td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td><strong>Conference rooms</strong></td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>

Normally supplied transfer air. Local mechanical exhaust with no re-circulation recommended. Normally supplied by transfer air.

Table 3 – Outdoor Air Requirements for Ventilation ¹) of Air Conditioned Areas and Commercial Facilities (Clause 29.2.3.4.5)

<table>
<thead>
<tr>
<th></th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elevators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Retail stores, sales floors and show room floors</strong></td>
<td>30</td>
<td>1.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Basement and street</strong></td>
<td>20</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Upper floors</strong></td>
<td>15</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Storage rooms</strong></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dressing rooms</strong></td>
<td>20</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Malls and arcades</strong></td>
<td>10</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shipping and receiving</strong></td>
<td>5</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Warehouses</strong></td>
<td>70</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smoking lounge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Normally supplied by transfer air, local mechanical exhaust; exhaust with no re-circulation.
### v) Specially shops

<table>
<thead>
<tr>
<th>Shop Type</th>
<th>Ventilation Rate</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barber shop</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>Beauty Parlour</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>Florists</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Cpoplothiers, furniture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware, drugs, fabric</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Pet shops</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.50</strong></td>
<td></td>
</tr>
</tbody>
</table>

Ventilation to optimize growth may dictate requirements.

### iv) Sports and Amusement

<table>
<thead>
<tr>
<th>Activity</th>
<th>Ventilation Rate</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectator areas</td>
<td>150</td>
<td>8</td>
</tr>
<tr>
<td>Game rooms</td>
<td>70</td>
<td>13</td>
</tr>
<tr>
<td>Ice arenas (playing areas)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swimming pools (pool and deck area)</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Playing floors (gymnasium)</td>
<td>100</td>
<td>13</td>
</tr>
<tr>
<td>Ballrooms and discos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bowling alleys (seating area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2.50</strong></td>
<td></td>
</tr>
</tbody>
</table>

When internal combustion engines are operated for maintenance of playing surfaces, increased ventilation rates may be required. Higher values may be required for humidity control.

### vii) Theatre

<table>
<thead>
<tr>
<th>Area</th>
<th>Ventilation Rate</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticket booths</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Lobbies</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>Auditorium</td>
<td>150</td>
<td>8</td>
</tr>
<tr>
<td>Stages, studios</td>
<td>70</td>
<td>8</td>
</tr>
</tbody>
</table>

Special ventilation will be needed to eliminate special stage effects (for example, dry ice vapours, mists, etc.)
### Transportation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Ventilation</th>
<th>Special Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting rooms</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Platforms</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td>150</td>
<td>Ventilation within vehicles may require special consideration</td>
</tr>
</tbody>
</table>

### Workrooms

<table>
<thead>
<tr>
<th>Activity</th>
<th>Ventilation</th>
<th>Special Requirements</th>
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<tbody>
<tr>
<td>Meat processing</td>
<td>10</td>
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### Education

<table>
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<tr>
<th>Activity</th>
<th>Ventilation</th>
<th>Special Requirements</th>
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<tbody>
<tr>
<td>Classrooms</td>
<td>50</td>
<td>Special contaminant control systems may be required for processes or functions including laboratory animal occupancy.</td>
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<tr>
<td>Laboratories</td>
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<td>Training shop</td>
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<td>Music rooms</td>
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<td>Libraries</td>
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<tr>
<td>Locker rooms</td>
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<td>Corridors</td>
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<tr>
<td>Auditoriums</td>
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xi) **Hospital, Nurses and Convalescent Homes**

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<tr>
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<th>13</th>
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<tbody>
<tr>
<td>Patient rooms</td>
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<td>8</td>
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<tr>
<td>Medical procedure</td>
<td>20</td>
<td>15</td>
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<tr>
<td>Operating rooms</td>
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<td>Procedure Recovery</td>
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<td>Autopsy</td>
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<td>Physical therapy</td>
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<tr>
<td>Correctional Cells</td>
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<tr>
<td>Dining Halls</td>
<td>40</td>
<td>8</td>
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<tr>
<td>Guard stations</td>
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Special requirements or Codes provisions and pressure relationships may determine minimum ventilation rates and filter efficiency. Generating contaminants may require higher rates.

Ventilation within vehicles may require special consideration.

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1] This table prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to dilute human bioeffluents and other contaminants with an adequate margin of safety and to account for health variations among people and varied activity levels.

2] Net occupyable space.

The degree of filtration necessary will depend on the use of the building or the conditioned space. Certain specialized equipment, normally associated with computers, will require higher than normal air filter efficiencies for satisfactory operation. It is important to ascertain the necessary standard of air cleanliness required for equipment of this type.

The choice of filtration systems will depend on the degree of contamination of the air and on the cleanliness required. A combination of filter types may well give the best service and the minimum operating costs.

The normal standard for intake filters in ventilating and air conditioning applications is an efficiency of 95 percent for a particle size up to 15 μm although there may be a requirement for a higher efficiency to give increased protection against atmospheric staining.

Special applications, such as computer server rooms, clean rooms, healthcare, pharmaceutical or food processing and air systems having induction units, require a higher standard that is achieved by two stage filtration. The exact requirements will depend on the equipment or process involved.

### 29.2.3.4.6.3 Removal of fumes and smells from air

Fumes and smells may be removed from air by physical or chemical processes. These may be essential when ambient air is heavily polluted.

The decision to use odour-removing equipment will normally be made on economic grounds; this may become necessary by the currently rising cost of fuel. Once such equipment is installed, it has to be regularly serviced to ensure satisfactory performance. Failure to do this may result in unacceptable conditions within the building.

### 29.2.3.5 Statutory regulation and safety considerations

#### 29.2.3.5.1 Authorities and approval of schemes

A ventilation or air conditioning system should comply with the requirements laid down in the current statutory legislation or any revisions currently in force and consideration should also be given to any relevant insurance company requirements.
29.2.3.5.2 Fire and safety considerations

Fire protection requirements of air conditioning systems shall be in accordance with this Code.

29.2.3.5.2.1 Design principles

The design of air conditioning system and mechanical ventilation shall take into account the fire risk within the building, both as regards structural protection and means of escape in case of fire.

The extent and detail of statutory control and other specialist interest may vary considerably according to the design, use, occupation and location of the building, and the type of system of mechanical ventilation and air conditioning proposed. It is therefore particularly important that the appropriate safeguards are fully considered at the concept design stage of the building. The degree of control and the requirements vary according to the application.

Full details may have to be approved by the Authority having jurisdiction in the following cases:

a) From the point of view of the means of escape (except dwelling houses) where re-circulation of air is involved and/or where pressurized staircases are contemplated as part of the smoke control arrangements;

b) Places of public entertainment, and

c) Large car parks, hotels, parts of building used for trades or processes involving a special risk, and departmental stores and similar shop risks in large buildings.

29.2.3.5.2.2 Ductwork and enclosures

All ductwork including connectors, fittings and plenums should be constructed of steel, aluminium or other approved metal or from non-combustible material. All exhaust ducts, the interior of which is liable in normal use to accumulate dust, grease or other flammable matter, should be provided with adequate means of access to facilitate cleaning and inspection. Also, the concerned provisions of Part 3 Use and Occupancy Classification of the Ghana Building Code shall be complied with.

29.2.3.5.2.3 Thermal and acoustic insulation

To reduce the spread of fire or smoke by an air conditioning system, care should be taken for the choice of materials used for such items as air filters, silencers and insulation both internal and external.

29.2.3.5.2.4 Fire and smoke detection

When the system involves the re-circulation of air, consideration should be given to the installation of detection devices that would either shut off the plant and close dampers or discharge the smoke-laden air to the atmosphere. Detectors may be advisable in certain applications even when the system is not a re-circulatory one. Exhausts should not be positioned near the fire escapes, main staircases or where these could be a hindrance to the work of fire authorities. The local fire authorities should be consulted.

A careful study of the operating characteristics of each type of sensing device should be made before selection. Smoke detectors are normally either of the optical or ionization chamber type. These can be used to either sound an alarm system or operate a fire damper. Care should be taken with their location as various factors affect the satisfactory operation.

Ionization type detectors are sensitive to high velocity air streams and if used in ductwork the manufacturer should be consulted. Activation of a smoke detector should stop the air handling unit supply air fan, close the fire damper in supply and return air duct and operate a suitable alarm system.

In all the above instances the appropriate controls would require manual re-setting.

29.2.3.5.2.5 Smoke control

While it is essential that the spread of smoke through a building to be considered in the design of air conditioning systems for all types of applications, it assumes special significance in high rise buildings, because the time necessary for evacuation may be greater than the time for the development of untenable smoke conditions on staircases, in lift shafts and in other parts of the building far away from the fire. Lifts may be filled with smoke or unavailable, and, if mass evacuation is attempted, a staircase may be filled with people.
One or more escape staircases connecting to outdoors at ground level, should be pressurized, to enable mass evacuation of high rise buildings. Therefore all air handling systems of a building should be designed with fire protection and smoke control aspects incorporating, where appropriate, facilities to permit their operation for the control of smoke within the building in event of fire. The pressurization systems for staircases use large volumes of outside air. The system may be designed to operate continuously at low speed, being increased to high speed in the event of fire, or to operate only in emergency. Noise and droughts are not considered a problem in an emergency situation. Fan motor and starter should be protected from fire and connected to the emergency electrical supply through cables with special fire resistant coating.

29.2.3.6 Application factors

29.2.3.6.1 General

This clause gives general guidance, for various applications, for the factors that usually influence the selection of the type, design and layout of the air conditioning or ventilating system to be used.

29.2.3.6.1.1 Commercial applications

The primary objective of the application described under this heading is the provision of comfort conditions for occupants.

29.2.3.6.1.2 Offices

Office building may include both external and internal zones.

The external zone may be considered as extending from approximately 4m to 6m inwards from the external wall, and is generally subjected to wide load variation owing to daily and annual changes in outside temperature and solar radiation. Ideally, the system(s) selected to serve an external zone should be able to provide hot season cooling and dry/cold season heating. During intermediate seasons the external zone of one side of the building may require cooling and at same time the external zone on another side of the building may require heating. The main factors affecting load are usually window area and choice of shading devices. The other important factors are the internal gain owing to people, light and office equipment. Choice of system may be affected by requirements to counteract down draughts and chilling effect due to radiation associated with single glazing during cold weather.

Internal zone loads are entirely due to heat gain from people, lights and office equipment, which represent a fairly uniform cooling load throughout the year.

Other important considerations in office block applications may include requirements for individual controls, partitioning flexibility serving multiple tenants, and requirement of operating selected areas outside of normal office hours. Areas such as conference rooms, board rooms, canteens, etc. will often require independent systems.

For external building zones with large glass areas, for example, greater than 60 percent of the external façade, the air-water type of systems, such as induction or fan coil is generally more economical than all air systems and has lower space requirements. For external zones with small glass areas, an all-air system, such as variable volume, may be the best selection. For buildings with average glass areas, other factors may determine the choice of system.

For internal zones, a separate all-air system with volume control may be the best choice. Systems employing reheat or air mixing, while technically satisfactory, are generally poor as regards energy conservation.

29.2.3.6.1.3 Hotel guest rooms

In ideal circumstances, each guest room in a hotel or motel should have an air conditioning system that enables the occupant to select heating or cooling as required to maintain the room at the desired temperature. The range of temperature adjustment should be reasonable but, from the energy conservation view point, should not permit wasteful overcooling or overheating.

Guest room systems are required to be available for operation on a continuous basis. The room may be unoccupied for most of the day and therefore provision for operating at reduced capacity, or switching off, is essential. Low operating noise level, reliability and ease of maintenance are essential. Treated fresh air introduced through the system is generally balanced with the bathroom extract ventilation to promote air circulation into the bathroom. In tropical climates, where the humidity is high an
all-air system with individual room reheat (and/or re-cool) may be necessary to avoid condensation problems. Fan coil units are generally found to be most suitable for this kind of application, with speed control for fan and motorized/modulating valve for chilled water control for cooling.

29.2.3.6.1.4 Restaurants, cafeteria, bars and night-clubs
Such applications have several factors in common; highly variable loads, with high latent gains (low sensible heat factor) from occupants and meals, and high odour concentrations (body, food and tobacco smoke odours) requiring adequate control of fresh air extract volumes and direction of air movement for avoidance of draughts and make up air requirements for associated kitchens to ensure an uncontaminated supply.

This type of application is generally best served by the all-air type of system preferably with some reheat or return air bypass control to limit relative humidity. Either self-contained packaged units or split systems, or air-handling unit served from a central chilled system may be used. Sufficient control flexibility to handle adequately the complete range of anticipated loads is essential.

29.2.3.6.1.5 Department stores/shops
For small shops and stores, unitary split type air conditioning systems offer many advantages, including low initial cost, minimum space requirement and ease of installation.

For large department stores, a very careful analysis of the location and requirement of each individual department is essential as these may vary widely, for example, for lighting departments, food halls, restaurants, etc. Some system flexibility to accommodate future changes may be required.

Generally, internal loads from lighting and people predominate. Important considerations include initial and operating costs, system space requirements, ease of maintenance and type of operating personnel who will operate the system.

The all-air type of system, with variable volume distribution from local air handling units, may be the most economical option. Facilities to take all outside air for ‘free-cooling’ under favourable conditions should be provided.

29.2.3.6.1.6 Theatres/auditoria
Characteristics of this type of application are buildings generally large in size, with high ceiling, low external loads, and high occupancy producing a high latent gain and having low sensible heat factor. These give rise to the requirements of large fresh air quantities and low operating noise levels. Theatres and auditoria may be in use only a few hours a day.

29.2.3.6.1.7 Special applications
29.2.3.6.1.7.1 Hospital/operating theatres
In many cases proper air conditioning can be a factor in the therapy of the patient and in some instances part of the major treatment. For special application areas of hospitals such as operation theatres, reference may be made to specialist literature.

The main differences in application compared with other applications are:

a) Restriction of air movement between various departments and control of air movement within certain departments, to reduce the risk of airborne cross infection;

b) Specific need for the ventilation and filtration equipment to dilute and/or remove particulate or gaseous contamination and airborne micro-organisms;

c) Close tolerances in temperatures and humidities may be required for various areas;

d) The design should allow for accurate control of environmental conditions.

For (a) and (b) the air movement patterns should minimize the spread of contaminants as for instance, in operating departments where the air flow should be such as to reduce the risk of periphery or floor-level air returning to the patient owing to secondary air currents whilst the general pressurization pattern should cause air to flow through the department from sterile to less sterile rooms in progression. In operating theatres 100 percent fresh air system is normally provided and air pressures in various rooms are set by use of pressure stabilizers. Many types of air distribution patterns within operation theatres
are in use but generally they conform to high-level supply and low-level pressure relief or exhaust. There is also need for a separate scavenging system for exhaled and waste anaesthetic gases with in theatre suites where general anaesthetic may be administered.

When zoning air distribution systems to compensate for building orientation and shape, consideration should be given to ensure that the mixing of air from different departments is reduced to a minimum. This can be accomplished by the use of 100 percent conditioned fresh air with no recirculation or, where re-circulation is employed, by providing separate air handling systems for different departments based on the relative sensitivity of each to contamination. A degree of stand-by is provided by this system so that breakdown will affect only a limited clause of the hospital.

Laboratories and other areas dealing with infectious diseases or viruses, and sanitary accommodation adjacent to wards, should be at a negative air pressure compared to any other area to prevent exfiltration of any airborne contaminants. In extreme cases any exhaust to atmosphere from these areas has to pass through high efficiency sub-micron particulate air (HEPA) filters.

29.2.3.6.1.7.2 Computer rooms

The equipment in computer rooms generate heat and contains components that are sensitive to sudden variations of temperature and humidity. These are sensitive to the deposition of dust. Exposure beyond the prescribed limits may result in improper operation or need for shut-down of the equipment. The temperature and humidity in computer rooms need to be controlled within reasonably close limits, although this depends on the equipment involved. The relative humidity may be controlled within + 5 percent in the range 40 percent to 60 percent. Manufacturers normally prescribe specific conditions to be maintained. Typical conditions are air dry-bulb: 21 ± 1.6°C; relative humidity 50 ± 5 percent; and filtration 90 percent down to 10 microns.

A low velocity re-circulation system may be used with 5 percent to 10 percent fresh air make-up which is allowed to exfiltrate from the room and ensure a positive pressure to prevent entry of dust and untreated air. The air distribution should be zoned to minimize temperature variations owing to fluctuation in heat load. Overhead air supply through ceiling plenums utilizing linear diffuser or ventilated ceilings is eminently suited to computer room application, permitting high air change rates to be achieved without undue discomfort to personnel.

The air conditioning system should be reliable because failure to maintain conditions for even a short duration can cause substantial monetary loss and possibly more serious consequence. As such, standby equipment is recommended.

29.2.3.6.1.8 Residential buildings

Very few residences are air conditioned. Some individual houses have unitary systems comprising of window/split air conditioners. Some large houses have VRV based splits and some luxury blocks of flats are provided with air-water systems. VAV also works well for some luxury applications with chilled water applications. In the latter case, most of the considerations of Clause 29.2.3.6.1.3 apply.

29.2.4 Noise and vibration control

29.2.4.1 General

Noise is unwanted sound. All ventilating and air conditioning systems will produce noise, and this may cause annoyance or disturbance in:

- a) the spaces being treated;
- b) other rooms in the building;
- c) the environment external to the building.

In the case of external environment particular care should be taken to avoid a nuisance in the ‘silent’ hours, and local authorities have statutory powers to ensure that noise from plant is limited.

It is important that expert advice be sought in dealing with noise and vibration problems, as for obvious reasons, the most economical solutions should be used, without impairing the performance.

29.2.4.2 Types of noise in building

29.2.4.2.1 Externally created noise

Reduction of externally created noise is mainly dealt with by choice of building profile and window construction. The air conditioning
designer should, however, ensure that noise does not enter via air inlets or exhausts; it may be reduced by suitable attenuators.

29.2.4.2.2 Generated noise

Noise produced by the components of air conditioning and ventilation plant installed within the building can escape via ventilation grilles or door openings and can cause nuisance to neighbours. Equipment mounted outside the building may well need to be selected or installed with the noise problem in mind.

Another type of generated noise is created by the air-circulating system itself and its associated equipment. Fans are an obvious source, but noise can be produced by turbulence, which may cause vibration of the ducts and noise transmission by air diffusers. This problem can be avoided by careful selection of and installation equipment or by the noise absorbing devices.

29.2.4.2.3 Transmitted noise

Noise transmitted through the building structure is particularly acute in modern frame and reinforced concrete buildings. Such noise can be controlled by isolating the machines from the structures, and from pipe work connected to the building, by suitable mountings and pipe couplings.

Another problem is the transmission of sound from one room to another via air ducting, ventilated ceilings or other continuous air space. Such sound includes the noise from machines and equipment and also of conversation, transmission of which can be embarrassing as well as annoying. Again, the problem can be tackled by careful design and the inclusion of sound absorbing devices in ducts.

29.2.4.2.4 Intermittent noise

Such noise arises from the stopping and starting of equipment, and the opening and closing of valves and dampers. This may or may not cause problems in the air conditioned spaces, but it is often objectionable to plant operators and maintenance engineers. This should be considered by the air conditioning designer.

29.2.4.3 The source of noise in the air conditioning system could be from the following:

- chillers;
- pumps;
- pipe supports;
- ducts;
- external noise in filtration through openings;
- fans;
- air noise through ducts; and
- compressors.

29.2.4.4 The approach must always be to reduce the source noise rather than controlling them in the path.

29.2.4.5 Noise control

29.2.4.5.1 From room air conditioners (RAC)

The following measures should be adopted:

- Selection of RAC which has the least noise at various fan speeds;
- Installation at a serviceable height;
- Installation preferably in a wall or on a rigid window;
- Provision of only necessary slope as specified by the manufacturer, to avoid any unusual noise from the compressor because of tilting;
- Installation preferably in the middle portion of the wall/window to avoid additional directivity (do not install at the end of a wall);
- Ensure all leaks are sealed properly;
- Avoid condenser facing any high noisy areas, such as road/factory to avoid any such noise predominantly entering into the room;
- Do not provide any props at the back side bottom of the air conditioner unless specified by the manufacturer;
- Preparation of opening to suit the chassis with wooden frame of adequate rigidity and thickness.

29.2.4.5.2 From split air-conditioner/furred inn

The following measures should be adopted:

- Install the evaporator only on a rigid wall/ceiling or on a pedestal.
- Avoid installation over wooden/gypsum board partition.
Should a need arise, anchor the evaporator rigidly by using mild steel framework from the roof to avoid vibration.

c) Provide proper 'u' trap in the condensate water line to ensure a good water seal, which will also avoid sound penetration into the room from outside.

d) If the capillary is in the evaporator, ensure that flow noise is avoided.

e) Ensure proper return air entry back to the coil, since blowers working at higher static pressure will create higher noise.

f) Select the condensers with top/side discharge depending upon location to avoid nuisance to neighbours.

g) Place condensers on rigid platform, properly supported, propped and fixed firmly.

h) Ensure all screws, bolts and nuts are firmly tightened since stiffening is more advantageous in higher frequencies for vibration reduction.

29.2.4.5.3 Air handling units (floor mounted and ceiling suspended)

The following measures should be adopted:

a) Select indoor machine for specific air quantity and static pressure.

b) Suspend the indoor machine and ducts without touching the members of the false ceiling or partitions.

c) Ensure that ducts/duct supports do not touch the evaporator.

29.2.4.5.4 From plenum chamber

The following measures should be adopted/considered:

a) If possible and if pressures allow, expand the air to a plenum chamber (of 2.5 m/s for normal office), which is acoustically lined inside.

b) Stiffening of the plenum body is very critical since it could create a drumming noise.

c) Plenum chambers with sound absorbing material are frequently used as silencers in air conditioning and ventilating systems and in testing facilities to reduce flow velocity and turbulence. The attenuation of these devices may be due to both dissipative and reactive effects.

29.2.4.5.5 From fans

29.2.4.5.5.1 Centrifugal fans

There are three basic types of centrifugal fans, backward curved, forward curved, and radial. Noise from centrifugal fans is dominantly a superimposition of discrete tones at the varying frequencies and broadband aerodynamic noise.

29.2.4.5.5.2 Axial fans

Axial fans derive their name from the fact that the airflow is along the axis of the fan. To avoid a circular flow pattern and to increase performance, guide vanes are usually installed downstream of the rotor. Axial fans with exit guide vanes are called vane axial and those without guide vanes are called tube axial. Axial fans generally operate at higher pressures than centrifugal fans and are usually considered noisier. Common applications include heating and ventilation systems. Because of the large number of blades and high rotational speeds, noise from axial fans is generally characterized by strong discrete blade passing tones.

Variable inlet vane system may generate significantly low frequency noise as the vanes shut down. Additional attenuation with a corresponding additional pressure drop is required to attenuate the noise generated by the inlet vanes.

Variable speed motors and drives and variable pitch fan blade systems are actually quieter at reduced air output than at full output. The designer has the option of designing for maximum output as if the system were constant volume, or selecting the sound attenuation for a more normal operating point and allowing fan noise to exceed the design criteria on the rare occasions when the fan operates at full output.

29.2.4.5.5.3 To reduce fan noise, the following should be adopted:

a) Design the air distribution system for minimum resistance, since the...
sound generated by a fan, regardless of type, increases by the square of the static pressure. Turbulence can increase the flow noise generated by duct fittings and dampers in the air distribution systems especially at low frequencies.

b) Examine the specific sound power levels of the fan designs for any given job. Different fans generate different levels of sound and produce different octave band spectra. Select a fan that will generate the lowest possible sound level, commensurate with other fan selection parameters.

c) Fans with relatively few blades (less than 15) tend to generate tones, which may dominate the spectrum. These tones occur at the blade passage frequency and its harmonies. The intensity of these tones depends on resonance with the duct system, fan design, and inlet flow distortions.

d) Select a fan to operate as near as possible to its rated peak efficiency when handling the required quantity of air and static pressure. Also, select a fan that generates the lowest possible noise but still meets the required design conditions for which it is selected. Using an oversized or undersized fan, that does not operate at or near rated peak efficiency, may result in substantially higher noise levels.

e) Design duct connections at both the fan inlet and outlet for uniform and straight airflow. Avoid unstable, gusting and swirling inlet airflow. Deviation from accepted applications can severely degrade both the aerodynamic and acoustic performance of any fan and invalidate manufacturer’s ratings or other performance predictions.

f) Select duct silencers that do not significantly increase the required fan total static pressure.

29.2.4.5.6 From chillers, pumps and pipes

Sizing and selecting a chiller is an important aspect in noise control. The following guidelines may be considered for noise control:

a) For roof top installation of chillers, these may be placed on beams connected on the elevated levels of pillars on correctly chosen vibration isolators.

b) Water cooled chillers have less vibration. However, if air cooled chillers have to be chosen, choose them with fans of lower speeds and compressors must be jacketed without compromising their ventilation requirement.

c) If much more silencing is required, plan a silencer on the exhaust of the fans and also an acoustic enclosure around the chillers. Care must be taken for the additional static demand in the fan.

29.2.4.5.7 From ducting work

The following measures should be adopted:

a) Shorter ducts with flanges and bracings are advantageous for noise reduction.

b) Choose the right thickness of sheets for ducting.

c) Provide calculated turning vanes in all bends.

d) Provide take off pieces in all branches and collars.

e) Minimize the number of terminals since each terminal of equal noise will create a higher overall noise inside the room – two equal noise sources increase the noise by 3 dB.

f) Velocities of supply and return ducts and also terminals are important for noise control.

g) For auditoriums, conference halls etc., choose the right silencers in the supply. Define a clear opening for return air and fix return air silencers (parallel baffle silencer). The pressure drop expected across these silencers
varies from 6 mm to 10 mm of water column.

h) Selecting double skin air handling unit should be done with care. If used without supply and return air silencers, it adds to the noise in the duct patch. However, by using double skin air handling units the noise inside the plant room can be lowered.

i) Instead of insulating the plant room, increasing the density of the plant room wall and providing return air baffles in the return air patch is more helpful in noise reduction. The doors to the air handling unit room should be either with an attic entry or dense enough to avoid noise transmission.

j) Avoid terminal dampers and grilles if the noise criterion is of the order of NC 20 (recording studios).

k) If ducts have to be routed outside the conditioned space, the density of the insulating materials over the duct surface is very critical. The higher the density, the lower is its transmittal of noise and hence break in noise inside the duct can be avoided. The density is to be decided based on the outside noise level.

l) Selection of a proper terminal device helps in noise reduction.

m) VAV shall be planned along with relevant VFD or bypass arrangement. Otherwise the duct is subjected to variable pressures resulting in variable noise pattern.

n) Minimize flow-generated noise by elbows or duct branch takeoffs, whenever possible, by locating them at least four to five duct diameters from each other. For high velocity systems, it may be necessary to increase this distance to up to ten duct diameters in critical noise areas.

o) Keep airflow velocity in the duct as low as possible (7.5 m/s or less) near critical noise areas by expanding the duct cross-clause area. However, do not exceed an included expansion angle of greater than 15°. Flow separation, resulting from expansion angles greater than 15°, may produce rumbling noise. Expanding the duct cross-clause area reduces potential flow noise associated with turbulence in these areas.

p) Use turning vanes in large 90° rectangular elbows and branch takeoffs. This provides a smoother transmission in which the air can change flow direction, thus reducing turbulence.

q) Place grilles, diffusers and registers into occupied spaces, as far as possible from elbows and branch takeoffs.

r) Minimize the use of volume dampers near grilles, diffusers and registers in acoustically critical situations.

s) Vibrationally isolate ducts and pipes, using spring and/or neoprene hangers for at least the first 15m from the vibration – isolated equipment.

29.2.4.6 Structure borne noise

Most obvious paths for solid-borne noise are the attached piping and pump support systems. Oscillatory energy generated near the pump can be conducted as solid-borne noise for substantial distances before it is radiated as acoustic noise. It can be controlled using flexible couplings and mechanical isolation.

29.2.4.7 Measurement

Measurements should be taken with a sound level meter either using the ‘A’ weighting scale or to draw up a noise criteria curve. Measurements should be taken in the following locations:

a) plant rooms;
b) occupied rooms adjacent to plant rooms;
c) outside plant rooms facing air intakes and exhausts and condenser discharge, to assess possible nuisance to adjacent occupied areas;
d) in the space served by the first grille or diffuser after a fan outlet; and
e) in at least two of the spaces served by fan coil units or high velocity system terminal units (where applicable).
29.2.5 Mechanical ventilation (for non air conditioned areas) and evaporative cooling

29.2.5.1 Ventilation

Ventilation is the process of changing air in an enclosed space. A proportion of the air in the space should be continuously withdrawn and replaced by fresh air drawn from outside to maintain the required level of air purity. Ventilation is required to control the following:

a) Oxygen content – Prevent depletion of the oxygen content of the air;

b) Carbon-dioxide and moisture – To prevent undue accumulation;

c) Contaminants – To prevent undue rise in concentration of body odours and other contaminants such as tobacco smoke;

d) Bacteria – To oxidize colonies of bacteria and fungi to prevent their proliferation.

e) Heat – To remove body heat and heat dissipated by electrical or mechanical equipment or solar heat gains.

Mechanical ventilation is one of several forms of ventilation options available. It usually consists of fans, filters, ducts, air diffusers and outlets for air distribution within the building. It may include either mechanical exhaust system or exhaust can occur through natural means.

Natural ventilation and natural exhaust are also options. The scope of this clause is therefore restricted to mechanical ventilation.

Ventilation controls heat, odours and hazardous chemical contaminants (in a building) that could affect the health and safety of the occupants. For better control of heat and contaminants, air may need to be exhausted at their sources by local exhaust systems. Usually such systems require lower air flows than general (dilution) ventilation.

The following considerations provide details regarding the various parameters that affect the type of ventilation system selected for a particular application, and the sizing of the ventilation plant:

a) The climatic zone in which the building is located is a major consideration. An important distinction that must be made is between hot-dry and warm-moist conditions. Hot-dry work situations occur around furnaces, forges, metal-extruding and rolling mills, glass-forming machines, and so forth.

Typical warm-moist operations are found in textile mills, laundries, dye houses, and deep mines where water is used extensively for dust control. Warm-moist conditions are more hazardous than hot-dry conditions.

b) Siting (and orientation) of the building is also an important factor. Solar heat gain and high outside temperature increases the load significantly; how significantly, depends on the magnitude of these gains particularly in relation to other gains, for example the internal load.

c) The comfort level required is another consideration. In many cases, comfort levels (as understood in the context of residential buildings, commercial blocks, office establishments) cannot be achieved at all and therefore, what is often aimed at will be ‘acceptable working conditions‘ rather than ‘comfort‘.

Having surveyed the considerations above, there are many options available in mechanical ventilation – spot cooling, local exhaust, changes in work pattern – to choose from, for achieving the desired acceptable working conditions. The options available may be extended to evaporative cooling in order to achieve more acceptable working conditions when confronted with more hostile environmental conditions.

It will be thus seen that there are many considerations involved in the selection and sizing of suitable ventilation and evaporative cooling plants to meet the requirements of any particular building and/or process. It is the interplay of these various factors listed above like climatic conditions, internal load, exposure to heat and hazardous substances and level of working conditions aimed at, that determines the option which best meets the requirement and also, the capacity and other attributes of the option selected.

1005
Ventilation control measures alone are frequently inadequate for meeting heat stress standards. Optimum solutions may involve additional controls, such as local exhausts, spot cooling, changes in work-rest patterns and radiation shielding.

As a rule, it is the mechanical system that provides the best results and controls for the more complex situations and more stringent requirements arising out of harsher environment and need for better working conditions.

29.2.5.2 Beneficial effects of ventilation

29.2.5.2.1 Fresh air supply

A ventilation system provides the fresh air flow that is required to maintain an acceptable non-odorous atmosphere (by diluting body odours and tobacco smoke) and to dilute the carbon dioxide exhaled.

The quantity and distribution of introduced outside air takes into account infiltration, exhaust and dilution requirements of the building. Proportion of fresh air introduced into a building may be varied to achieve economical operation. When fresh air can provide the usual cooling effect, the quantity should be controlled to match the cooling demand.

29.2.5.2.2 Transfer of heat/moisture

Ventilation systems help air circulation that is required to transfer the heat and humidity generated within the building. Heat generated by the occupants, electrical and mechanical equipment, and solar heat gains may be removed by the introduction of adequate quantities of fresh air and by expelling or extracting of stale air.

29.2.5.2.3 Air movement

Ventilation systems provide air movement that is necessary to create a feeling of freshness and avoid discomfort, although excessive movement should be avoided as this may lead to complaints of draughts. The quantity of fresh air should not be increased solely to create air movement; this should be effected by air re-circulation within the space or by inducing air movement with the ventilation air system.

Air flow should be controlled to minimize transfer of fumes and smells. In addition, air pressure gradients may be created within the building, by varying the balance between the fresh air and extracting the stale air.

Care should be taken, however, to avoid excessive pressure differences that can cause difficulty in opening doors or cause them to slam.

29.2.5.2.4 Air purity and filtration

Ventilation system installed in a building should deliver clean, fresh air to the space served. This may be achieved by providing the required amount of fresh air either to remove totally or to dilute odours, fumes, etc. Local extract systems may be necessary to remove polluted air from kitchens, toilets, slaughter houses, crematoria, etc. Special air filters may be provided to remove contaminants or smell when air is re-circulated.

29.2.5.2.5 Removal of particulate matter from air

Efficient air filtration to prevent fouling of the system should be considered, where damage is likely to be caused by discoloration owing to airborne dust particles. In order to obtain the best performance from the filters provided, care should be taken to locate the air intake appropriately in relation the prevailing wind, position of chimneys and relative atmospheric dust concentration in the environs of the building.

This will promote cleaner interiors and reduce dust loading of the filters. Adequate (space) provisions should be incorporated in plant layouts to ensure that filters can be serviced regularly.

29.2.5.2.6 Fire and smoke control

Ventilation systems can be designed to extract smoke in the event of a fire, to assist in the fire fighting operations and to introduce fresh air to pressurize escape routes.

29.2.5.2.7 Removal of fumes and smells from air

Fumes and smell may be removed from air by physical or chemical processes. Their removal may be essential when the ambient air is heavily polluted, although consideration must be given to limit the thermal loads caused by the introduction of large quantities of fresh air.
29.2.5.3 Industrial ventilation

Industrial buildings form a major application of mechanical ventilation.

In industrial buildings, ventilation is needed to provide the fresh air normally required for health and hygiene and also, to mitigate thermal working conditions by assisting in the removal of surplus heat due to equipment, people and building heat gains. The following are some of the factors that should be considered in the system design:

a) A supply system would not be satisfactory without a complimentary exhaust system. Similarly any exhaust system would require a complementary supply system.

b) Air should be supplied equitably through grilles, diffusers and such other devices. Directional grilles, diffusers and nozzles designed specifically to alleviate the thermal conditions should be considered. Drafts should be avoided.

c) Ventilation systems may need to be supplemented by exhaust hoods and canopies designed to capture the unwanted fumes or dust right at the source irrespective of other air currents in the vicinity.

Many industrial ventilation systems shall handle simultaneous exposures to heat, toxic and hazardous substances. The number of contaminant sources, their generation rate and effectiveness of exhaust hoods are rarely known; there is no option but to depend on common ventilation/industrial hygiene practice in such situations.

Reference may also be made to good practice.

29.2.5.4 Types of ventilation systems

In the interest of efficient use of energy and comfort to occupants, it is imperative that all modes of ventilation should be considered in relation to the thermal characteristics of the building.

29.2.5.4.1 Mechanical extract/natural supply

This is the simplest form of extract system comprising one or more fans, usually of the propeller, axial flow or mixed flow type, installed in outside walls or on the roof. The discharge should terminate in louvers or cowls or a combination of both.

Alternatively, the system may comprise of ductwork arranged for general extraction of the vitiated air or for extraction from localized sources of heat, moisture, odours, fumes and dust. Such duct work may be connected to centrifugal or axial flow fans that discharge through the wall or roof, terminating in louvers or cowls or a combination of both.

It is essential that provision for make-up air is made and that consideration is given to the location and size of inlets. Inlets should not be located in the vicinity of exhaust fans.

29.2.5.4.2 Mechanical supply/natural extract

This system is similar in form to the extract system but arranged to deliver fresh air positively into the enclosed space. Such a system necessitates provision for the discharge of vitiated air by natural means. Where there is a requirement for the enclosed space to be at a slightly higher pressure than its surroundings (to exclude dust or smoke, for example), the discharge may be through natural leakage paths or balanced pressure relief dampers, as may be required.

29.2.5.4.3 Combined mechanical supply and extract

This system is a combination of those described above and may comprise supply and exhaust ductwork systems or may employ a common fan with a fresh air inlet on the low pressure side.

29.2.5.5 Ventilation rate and design consideration for non-air conditioned areas

29.2.5.5.1 General ventilation

The rate of air circulation recommended for different general areas is as given in Table 4.

Table 4: Recommended rate of air circulation for different areas
(Clause 29.2.5.5.1)
<table>
<thead>
<tr>
<th>Application</th>
<th>Air Charge per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Assembly rooms</td>
<td>4-8</td>
</tr>
<tr>
<td>2. Bakeries</td>
<td>20-30</td>
</tr>
<tr>
<td>3. Banks/building societies</td>
<td>4-8</td>
</tr>
<tr>
<td>4. Bathrooms</td>
<td>6-10</td>
</tr>
<tr>
<td>5. Bedrooms</td>
<td>2-4</td>
</tr>
<tr>
<td>6. Billiard rooms</td>
<td>6-8</td>
</tr>
<tr>
<td>7. Boiler rooms</td>
<td>15-30</td>
</tr>
<tr>
<td>8. Cafes and coffee bars</td>
<td>10-12</td>
</tr>
<tr>
<td>9. Canteens</td>
<td>8-12</td>
</tr>
<tr>
<td>10. Cellars</td>
<td>3-10</td>
</tr>
<tr>
<td>11. Churches</td>
<td>1-3</td>
</tr>
<tr>
<td>12. Cinemas and theatres</td>
<td>10-15</td>
</tr>
<tr>
<td>13. Club rooms</td>
<td>12,Min</td>
</tr>
<tr>
<td>14. Compressor rooms</td>
<td>10-12</td>
</tr>
<tr>
<td>15. Conference rooms</td>
<td>8-12</td>
</tr>
<tr>
<td>16. Dairies</td>
<td>8-12</td>
</tr>
<tr>
<td>17. Dance halls</td>
<td>12,Min</td>
</tr>
<tr>
<td>18. Dye works</td>
<td>20-30</td>
</tr>
<tr>
<td>19. Electroplating shops</td>
<td>10-12</td>
</tr>
<tr>
<td>20. Engine rooms</td>
<td>15-30</td>
</tr>
<tr>
<td>21. Entrance halls</td>
<td>3-5</td>
</tr>
<tr>
<td>22. Factories and workshops</td>
<td>8-10</td>
</tr>
<tr>
<td>23. Foundries</td>
<td>15-30</td>
</tr>
<tr>
<td>24. Garages</td>
<td>6-8</td>
</tr>
<tr>
<td>25. Glass houses</td>
<td>25-60</td>
</tr>
<tr>
<td>26. Gymnasium</td>
<td>6,Min</td>
</tr>
<tr>
<td>27. Hair dressing saloon</td>
<td>10-15</td>
</tr>
<tr>
<td>28. Hospitals-sterilising</td>
<td>15-25</td>
</tr>
<tr>
<td>29. Hospital-wards</td>
<td>6-8</td>
</tr>
<tr>
<td>30. Hospital domestic</td>
<td>15-20</td>
</tr>
<tr>
<td>31. Laboratories</td>
<td>6-15</td>
</tr>
<tr>
<td>32. Launderettes</td>
<td>10-15</td>
</tr>
<tr>
<td>33. Laundries</td>
<td>10-30</td>
</tr>
<tr>
<td>34. Lavatories</td>
<td>6-15</td>
</tr>
<tr>
<td>35. Lecture theatres</td>
<td>5-8</td>
</tr>
<tr>
<td>36. Libraries</td>
<td>3-5</td>
</tr>
<tr>
<td>37. Living rooms</td>
<td>3-6</td>
</tr>
<tr>
<td>38. Mushroom houses</td>
<td>6-10</td>
</tr>
<tr>
<td>39. Offices</td>
<td>6-10</td>
</tr>
<tr>
<td>40. Paint shops (not cellulose)</td>
<td>10-20</td>
</tr>
<tr>
<td>41. Photo and X-ray darkroom</td>
<td>10-15</td>
</tr>
<tr>
<td>42. Public house bars</td>
<td>12,Min</td>
</tr>
<tr>
<td>43. Recording control rooms</td>
<td>15-25</td>
</tr>
<tr>
<td>44. Recording studios</td>
<td>10-12</td>
</tr>
<tr>
<td>45. Restaurants</td>
<td>8-12</td>
</tr>
<tr>
<td>46. School rooms</td>
<td>5-7</td>
</tr>
<tr>
<td>47. Shops and warehouses</td>
<td>8-15</td>
</tr>
<tr>
<td>48. Shower baths</td>
<td>15-20</td>
</tr>
<tr>
<td>49. Stores and warehouses</td>
<td>3-6</td>
</tr>
<tr>
<td>50. Squash courts</td>
<td>4,Min</td>
</tr>
<tr>
<td>51. Swimming baths</td>
<td>10-15</td>
</tr>
<tr>
<td>52. Toilets</td>
<td>6-10</td>
</tr>
<tr>
<td>53. Utility rooms</td>
<td>15-20</td>
</tr>
</tbody>
</table>
54. Welding shops 15-30

Note: The ventilation rates may be increased by 50 percent where heavy smoking occurs or if the room is below ground.

29.2.5.5.2 Kitchen (industrial and commercial) ventilation

Desired ventilation rates in the kitchen depend upon the type of equipment in use and the released impurity loads (including surplus heat). Ventilation standards set up the guide lines for ventilation volumes, whereas surplus heat and impurity loads determine the actual airflows based on thermal considerations. The design for kitchen airflow must allow for sufficient ventilation.

Table 5: Design exhaust air flow in l/s per kW of the kitchen equipment

<table>
<thead>
<tr>
<th>Kitchen Equipment</th>
<th>Electricity based Equipment</th>
<th>Gas based Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Cooking pot</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>ii) Pressure cooker cabinet</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>iii) Connection oven</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>iv) Roasting oven (salamander)</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>v) Griddle</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>vi) Frying pan</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>vii) Deep fat fryer</td>
<td>28</td>
<td>-</td>
</tr>
<tr>
<td>viii) Cooker/stove</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>ix) Grill</td>
<td>50</td>
<td>61</td>
</tr>
<tr>
<td>x) Heated table/bath</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>xi) Coffee maker</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>xii) Dish washer</td>
<td>17</td>
<td>-</td>
</tr>
<tr>
<td>xiii) Refrigeration equipment</td>
<td>60</td>
<td>-</td>
</tr>
<tr>
<td>xiv) Ceramic cooker/stove</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>xv) Microwave oven</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>xvi) Pizza oven</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>xvii) Induction cooker/stove</td>
<td>20</td>
<td>-</td>
</tr>
</tbody>
</table>

It is desirable to use compensating exhaust hoods for kitchen equipment installed within air conditioned spaces. The ventilation rates may be confirmed from the kitchen equipment supplier.

29.2.5.5.3 Car parking ventilation

Ventilation is essential, in car parking areas, to take care of pollution due to emission of carbon monoxide, oxides of nitrogen, presence of oil and petrol fumes and diesel engine smoke. These contaminants cause undesirable effects like nausea, headache and fire hazards, if applicable permissible limits for each of the contaminants noted are exceeded. Although four contaminants are listed above, the capacity of a system designed to tackle concentration of carbon monoxide, will be adequate to keep the other three contaminants also within their respective permissible limits.

The recommended ventilation rate will ensure that the CO level will be maintained within 29 mg/m³ with peak levels not to exceed 137 mg/m³.

For partially open garages, the requirement is stated in terms of area of wall/slab openings required to provide adequate ventilation. The value applicable is 2.5 percent to 5 percent of the floor area for free opening.
It is necessary to ensure at planning stage itself that adequate head room is available in the car parks for installing ventilation ducts if such ducting is involved.

29.2.5.4.4 Sizing the plant

Sizing the ventilation plant is essentially arriving at the air flow rate required. Based on various considerations already reviewed, the sizing of the plant will be influenced by the following requirement:

a) removal of sensible heat;

b) removal of latent heat;

c) make-up air – the flow rate required will depend upon local exhaust; and

d) removal or dilution of the contaminants down to the permissible level.

The air flow rate arrived at will be the maximum of the flow rates calculated for the above requirements.

29.2.5.4.4.1 Ventilation plant size is often expressed in terms of number of air changes per hour or cmh/m² of floor area. These expressions fail to evaluate the actual heat release provided by the plant. The unit, cmh/m² gives a relationship which is independent of the building height. This is a more rational approach than speaking in terms of air changes per hour. This is because, with the same internal load, the same amount of ventilation air, properly applied to the work zone with adequate velocity, will provide the desired heat relief quite independently of the ceiling height of the space, with few exceptions. Ventilation rates of 30 to 60 m³/h per m² have been found to give good results in many plants. Notwithstanding these general observations, detailed design should be based on detailed calculations after all necessary data have been evaluated and relevant considerations have been reviewed.

29.2.5.6 Evapourative cooling

29.2.5.6.1 Evapourative cooling is defined as the reduction of air dry-bulb temperature by the evapouration of water.

29.2.5.6.2 When water evaporates into the air to be cooled, simultaneously humidifying it, the process is called direct evapourative cooling. When the air to be cooled is kept separate from the evapouration process, and therefore is not humidified as it is cooled, then the process is called indirect evapourative cooling.

It is good practice to use 100 percent fresh air in the evapourative cooling. Re-circulation is not recommended, as it will lead to continuous increase in wet-bulb temperature of the air. When evapourative cooling is provided for comfort application, it may be supplemented by devices like ceiling fans and fan coolers to enhance air movement for circulation of air in internal areas in order to maximize evapouration of moisture from the skin.

29.2.5.6.3 The geographic range for the evapourative cooling is based on the cooler’s ability to create or approximate human comfort and is limited by relative humidity in the atmosphere. It is more effective in dry climates (hot-dry climate zone) where wet-bulb depression is comparatively large.

Factors to be considered – include those listed in 29.2.5.5.4; in addition the following also apply:

a) saturation efficiency of the cooler – higher the better;

b) ambient weather design data;

c) permissible temperature rise; and

d) type of cooling application – residential, industrial, etc.

29.2.5.6.4 The cooling load control, especially for industrial application shall be carried out in the following manner for effective evapourative cooling:

a) Minimize external heat loads by shading, use of heat reflective paints, roof insulation and sealing of gaps.

b) Minimize internal heat loads by shielding, use of reflective paints, insulation and installation of exhaust fans over the hot processes and machines.

c) Make building tight.

d) Wherever possible, exhaust of used washed air must be directed towards roof to partly cool the surface and trusses thereby reducing heat radiation.

29.2.5.6.5 Two types of water distribution systems may be provided:
a) once through or pump-less type; 
b) re-circulating or pump type.

The first type is simpler and cheaper but consumes more water, needs constant drainage and has lower efficiency depending upon the temperature of water. The second type has higher cooling efficiency due to re-circulated water approaching wet-bulb temperature conserves water and can operate with intermittent drainage. It is recommended to provide periodic bleeding or blow down to remove accumulated mineral additions. This helps in reducing scaling of pads also.

29.2.5.6 The air velocity across wetting pad is recommended between 1.0 and 1.5 m/s. The lower face velocity reduces evaporation as damp air film isolates the dry air from the wet surface. Higher face velocity may provide insufficient air-water contact time.

29.2.5.6.7 Pad material should be such which provides maximum clean wet surface area with minimum airflow resistance. Materials, which have either good ‘wick’ characteristics or surface that spread water rapidly by capillary action, should be selected.

29.2.5.6.8 In the ducted systems, all supply air diffusers, grilles and registers should be preferably adjustable.

29.2.5.6.9 General room cooling should be supplemented with spot cooling in the hot workplaces.

29.2.5.6.10 Reference may also be made to good practice

29.2.5.7 Planning

29.2.5.7.1 Planning of equipment room for ventilation

29.2.5.7.1.1 In selecting the location of equipment room, aspects of efficiency, economy and good practice should be considered and wherever possible, it shall be made contiguous with the building. This room shall be located as centrally as possible with respect to the area served and shall be free from obstructing columns.

Proper location helps achieve satisfactory air distribution and also results in a less expensive installation.

29.2.5.7.1.2 Equipment room should preferably be located adjacent to external wall to facilitate equipment movement and ventilation. It should also be close to the main electrical panel of the building, if possible, in order to avoid large cable lengths.

29.2.5.7.1.3 Location and dimensions of shafts, for ducting, cables, pipes, etc. (if envisaged), should be planned at the virtual stages itself of planning. They should be located adjacent to the equipment or within the room itself.

Evapourate cooling units (air washers) should be located preferably on heat season-windward side. They should be painted white or with reflective coating or thermally insulated, so as to minimize solar heat absorption.

In locating the units, care should be taken to ensure that their noise level will not be objectionable to the neighbours. Appropriate acoustic treatment should be considered, if the noise levels cannot be kept down to permissible limits.

Exhaust air devices, preferably to leeward and overhead side may be provided for effective movement of air.

In the case of large installations it is advisable to have a separate isolated equipment room if possible.

The equipment room should be adequately dimensioned keeping in view the need to provide required movement space for personnel, space for entry and exit of ducts, the need to accommodate air intakes and discharge, operation, maintenance and service requirements.

29.2.5.7.1.4 The floors of the equipment rooms should be light coloured and finished smooth. For floor loading, the air conditioning, heating and ventilation engineer should be consulted.

Arrangements for draining the floors shall be provided. The trap in the floor drain shall provide a water seal between the equipment room and the drain line. Water proofing shall be provided for floor slabs of equipment rooms housing evapourative cooling units.

29.2.5.7.1.5 Supporting of pipes within equipment room spaces should normally be
from the floor. However, outside equipment room areas, structural provisions shall be made for supporting the water pipes from the floor/ceiling slabs. All floor and ceiling supports make-up and drain connections pipes, ducting cables/cable trays, etc. shall be isolated from the structure to prevent transmission of vibrations.

29.2.5.7.1.6 Plant machinery in the plant room shall be placed on plain/reinforced concrete foundation and provided with anti-vibratory supports. All foundations should be protected from damage by providing epoxy coated angle nosing. Seismic restraints requirement may also be considered.

29.2.5.7.1.7 Wherever necessary, acoustic treatment should be provided in plant room space to prevent noise transmission to adjacent occupied areas.

29.2.5.7.1.8 In case the equipment is located in a basement, equipment movement route shall be planned to facilitate future replacement and maintenance. Service ramps or hatch in ground floor slab should be provided in such cases. Also arrangements for floor draining should be provided.

The trap in the floor drain shall provide a water seal between the equipment room and the drain line.

29.2.5.7.1.9 In the case of large and multi-storeyed buildings, independent ventilation/air washer units should be provided for each floor. The area to be served by the air-handling unit should be decided depending upon the provision of fire protection measures adopted. The units should preferably be located vertically one above the other to simplify location of pipe shafts, cable shafts and drainers.

29.2.5.7.1.10 Openings of adequate size should be provided for intake of fresh air. Fresh air intake shall have louvers having rain protection profile, with volume control damper and bird screen.

29.2.5.7.1.11 Outdoor air intakes and exhaust outlets shall be effectively shielded from the weather and insects.

29.2.5.7.1.12 In all cases, air intakes shall be so located as to avoid contamination from exhaust outlets or from sources whose contamination concentration levels are greater than normal in the locality in which the building is located.

29.2.5.7.1.13 Supply/return air duct shall not be taken through emergency fire staircase. However, exception can be considered if fire isolation of ducts at wall crossings is carried out.

29.2.5.7.1.14 Where necessary, structural design should avoid beam obstruction to the passage of supply and return air ducts. Adequate ceiling space should be made available outside the equipment room to permit installation of supply and return air ducts and fire dampers at equipment room wall crossings.

29.2.5.7.1.15 Access doors to equipment rooms should be through single/double leaf type, air tight, opening outwards and should have a sill to prevent flooding of adjacent occupied areas.

29.2.5.7.1.16 It should be possible to isolate the equipment room in case of fire. The door shall be fire resistant. Fire/smoke dampers shall be provided in supply/return air duct at air handling unit room wall crossings and the annular space between the duct and the wall should be fire sealed using appropriate fire resistance rated material.

29.2.5.7.2 In the planning stages itself, provision should be made for the following (if they are envisaged):

   a) space/routing/supports, etc. for ducting; and
   b) opening in walls, slabs, roof etc. for passage of ducts, pipes, cables, etc., for air intake, air exhaust, etc.

29.2.5.7.3 Bleed-off and chemical water treatment, depending on quality of water available for make-up, should be planned.

29.2.6 Unitary air conditioner

29.2.6.1 These are self-contained air conditioning units comprising a compressor and evaporator with fans for evaporator and air-cooled condenser. Unitary air conditioners are generally installed in windows and therefore they are also known as window air conditioners. It is designed to provide free delivery of conditioned air to an enclosed
space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulation and filtration of air. It may also include provision to exhaust room air as also induce fresh air for ventilation in the room. In addition to a basic cooling unit, there are several other optional features available, such as:

a) Means for heating during winter months;
b) Reciprocating or rotary compressor;
c) Swing louvers for better distribution of air in the room;
d) In addition to normal, dust filters, indoor air quality filters, such as bactericidal enzyme filters for killing bacteria, low temperature catalyst filter for removal of unpleasant odours, electrostatic filters to trap particles of smoke as well as suspended matters present in the air;
e) Digital LCD remote control which also indicates room temperature.

29.2.6.2 Capacity
Most of manufacturers supply unitary air conditioners in capacities of 3 500 W (1 TR), 5 250 W (1.5 TR) and 7000 W (2 TR). However, some of them may be able to supply window air conditioners of 1750 W (0.5 TR) and up to 10500 W (3 TR) along with intermediate range. The capacity of window air conditioners is rated at outside dry bulb temperature of 35°C and wet bulb temperature of 30°C and they are suitable for 230 V, single phase 50 Hz power supply. Nominal capacity of all the window air conditioners has to be de-rated due to high ambient temperatures in the hot months in most of Ghanaian cities. Also, generally a voltage stabilizer has to be installed to ensure that window air conditioner gets stabilized rated voltage.

29.2.6.3 Suitability
Unitary air conditioners are suitable for bedrooms, office cabins, general office area, hotel rooms and similar applications where normal comfort conditions are required up to a distance of 6m from unitary air conditioner.

29.2.6.4 Power consumption
Power consumption of window air conditioners of 1 TR (3500 W) rated capacity should not exceed 1.55 kW/TR. However, in smaller sizes, the power consumption may exceed. Rotary compressors normally consume 7 percent to 8 percent less power compared to the above value for reciprocating compressors.

29.2.6.5 Noise level
Noise level of window air conditioner inside the conditioned room should be as low as possible. However, it should not exceed 65 dBA for 5250 W (1.5 TR) or smaller capacity window air conditioners. Air conditioners with rotary compressors will have lower noise levels as compared to those provided with reciprocating compressors.

29.2.6.6 Location
Unitary air conditioners should be mounted preferably at the window sill level on an external wall where hot air from air – cooled condenser may be discharged without causing nuisance. There should not be any obstruction to the inlet and discharge air of the condenser. Also while deciding the location of the window air conditioners, care should be taken to ensure that the condensate water dripping does not cause nuisance. The opening for the air conditioner is generally made a part of windows or wall construction at the planning stage.

29.2.6.7 Limitations
Room air conditioners are not generally recommended in the following situations:

a) The width of the area exceeds 6m;
b) Area requiring close control of temperature and relative humidity;
c) Internal zones where no exposed wall is available for the installation of room air conditioners;
d) Sound recording rooms where criteria for acoustics are stringent;
e) Special applications like sterile rooms for hospitals and clean room applications where high filtration efficiency is desired;
f) Operation theatres where 100 percent fresh air is needed and fire hazard exists depending on the type of anaesthesia being used;
g) Where required to comply with the recommended fresh air requirement for ventilation.

29.2.6.8 For detailed information regarding constructional and performance requirements and methods for establishing ratings of room air conditioners, reference may be made to accepted standards.
29.2.7 Split air conditioner

29.2.7.1 Split air conditioner has an indoor unit and an outdoor unit interconnected with refrigerant piping and power and control wiring. The indoor unit comprises of a filter, evaporator and evaporator fan for circulation of air in the conditioned space. The outdoor unit has a compressor, air-cooled condenser with condenser fan housed in a suitable cabinet for outdoor installation. The split air conditioner includes primary source of refrigeration for cooling and dehumidification and means for circulation and cleaning of air, with or without external air distribution ducting.

Split air conditioners may be provided with either reciprocating compressors or scroll compressors. Scroll compressor generally consumes about 10 to 12 percent less power compared to reciprocating compressor.

Various split air conditioners available may be categorized as under:

a) Exposed indoor unit, which is either a high wall unit or a floor-mounted unit;

b) Furred-in units (ceiling suspended unit), which is mounted in the ceiling and provided with a duct collar and grille;

c) Ducted indoor unit, which requires ducting for air distribution.

29.2.7.2 Suitability

Split air conditioners are suitable for wide range of applications including residences, small offices, clubs, restaurants, showrooms, departmental stores, etc.

29.2.7.3 Capacity

Split air conditioners are available in the following capacities:

a) Indoor exposed units, 3500 W (1 TR), 5250 W (1.5 TR), 7000 W (2 TR) or two indoor units of 3500 W (1 TR) or 5250 W (1.5 TR), connected with one outdoor unit of 7000 W (2 TR) or 105000 W (3 TR) capacity. These units are available with corded and cordless remote control.

b) Furred-in units are available in capacities of 3500 W (1 TR) and 5250 W (1.5 TR) and may be provided with one outdoor unit or two outdoor units with two furred-in indoor units. These units are available with corded and cordless remote control.

c) Ducted split air conditioners (ceiling suspended ducted units) are available in capacities of 10500 W (3 TR), 17500 W (5 TR), 26250 W (7.5 TR) and 52500 W (15 TR). Ducted split air conditioners with scroll compressors are available in capacities of 19250 W (5.5 TR) and 29750 W (8.5 TR).

29.2.7.4 Location

Split air conditioner indoor unit is mounted within the air conditioned space or above the false ceiling from where the air distribution duct is taken to the conditioned space to distribute the air. When the indoor unit is mounted in the false ceiling, an inspection panel must be kept in the false ceiling to attend to the indoor unit including periodic cleaning of air filter. An outdoor unit is mounted at the nearest open area where unobstructed flow of outside air is available for the air cooled condenser.

29.2.7.5 Installation

Ceiling suspended indoor units are provided with rubber grommet to reduce vibration. Outdoor units are mounted on a steel frame in an open area so that the fan of the air cooled condenser can discharge hot air to the atmosphere without any obstruction. Care should be taken to ensure that free intake of air is available to the outdoor air cooled condenser. Also precaution should be taken that hot air from any other outdoor unit does not mix with the intake of the other outdoor air cooled condenser.

29.2.7.6 Limitations

Split air conditioners are generally not recommended for:

a) For areas where fresh air is required for ventilation.

b) Where distance between indoor exposed unit or furred-in unit exceeds 5m from the outdoor unit for units up to 7000 W (2 TR)
capacity. For larger ducted split air conditioners, the vertical distance between the indoor unit and the outdoor unit should not exceed about 6m for units with reciprocating compressors. The horizontal distance between the indoor unit and outdoor unit should not exceed about 10m for reciprocating compressors.

c) Area requiring close control of temperature and relative humidity.

d) Sound recording rooms where criteria for acoustics are stringent.

e) Special applications like sterile rooms for hospitals and clean room applications where high filtration efficiency is desired.

f) Large multi-storey buildings where multiplicity of the compressors may entail subsequent maintenance problems.

g) Where the length of air distribution ducting may exceed about 20 m.

29.2.7.7 Reference may be made to accepted standards.

29.2.8 Packaged air conditioner

29.2.8.1 Packaged air conditioner is a self-contained unit primarily for floor mounting, designed to provide conditioned air to the space to be conditioned. It includes prime source of refrigeration for cooling and dehumidification and means for circulation and cleaning of air, with or without external air distribution ducting. It may also include means for heating, humidifying and ventilating air.

The unit comprises a compressor, condenser and evaporator, which are interconnected with copper refrigerant piping and refrigerant controls. It also includes a fan for circulation of air and a filter. The unit is provided with a compressor and a fan motor starter and factory-wired safety controls.

A compressor is a device, which compresses low-pressure low temperature refrigerant gas to high-pressure high temperature super heated refrigerant gas. Compressors maybe of the reciprocating type or scroll type for packaging unit applications.

A condenser condenses high pressure high temperature refrigerant gas to liquid refrigerant at approximately the same temperature and pressure by removal of sensible heat of refrigerant by external means of water cooling or air cooling.

The packaged units are also available with microprocessor-based controller installed in the unit for digital display of faults as also several other functions. The packaged unit can also be provided with cold weather heating package or humidification package. The packaged unit may be provided with either water-cooled condenser or a remote air cooled condenser with interconnected copper refrigerant piping. The units are available with reciprocating compressor as also scroll compressor, which consume about 10 to 12 percent less power. In a water-cooled condenser unit, condenser-cooling water is circulated through the cooling tower with necessary piping and pumps sets.

The water cooled condenser packaged unit gives higher capacity at lower power consumption as compared to an air cooled condenser packaged unit which gets considerably de-rated in capacity and also consumes more power in peak heat season months in most of the cities of our country due to high ambient temperature.

Packaged units are generally available with vertical air discharge or horizontal air discharge.

29.2.8.2 Suitability

Packaged units are suitable for wide range of applications including offices, clubs, restaurants, showrooms, departmental stores, and computer rooms, etc.

29.2.8.3 Capacity

Normally the packaged air conditioners are manufactured in sizes of 17500 W (5 TR), 26250 W (7.5 TR), 35000 W (10 TR) and 52500 W (15 TR). Packaged units with scroll compressors are also available in capacities up to 58100 W (16.6 TR).

29.2.8.4 Location

The packaged unit can be mounted within the air conditioned space with discharge air plenum or in a separate room from where the air distribution duct is taken to the conditioned space. While deciding the location for the
packaged unit, provision must be kept for proper servicing of the unit.

29.2.8.5 Installation
The packaged units are normally mounted on a resilient pad which prevents vibration of the unit from being transmitted to the building.

29.2.8.6 Limitations
Packaged air conditioners are not generally recommended for:

a) Large multi-storey buildings where multiplicity of the compressors may entail subsequent maintenance problems.

b) Where the length of air distribution ducting may exceed approximately 20 m.

c) Where the vertical distance of air-cooled condenser from the packaged unit exceeds about 10 m. The sum of horizontal and vertical distances should be generally kept within 15 m.

d) Special applications like sterile rooms of hospitals and clean room applications where high filtration efficiency is desired.

e) Operation theatres where 100 percent fresh air is needed and fire hazard exists depending on the type of anesthesia being used.

29.2.8.7 For detailed information regarding constructional and performance requirements and methods for establishing ratings of packaged air conditioners, reference may be made to accepted standards in this Code.

29.2.9 Heating

29.2.9.1 The installation of an air-conditioning system may be used advantageously for the central heating system with additions such as hot water or boiler and hot water coils or strip heater banks.

29.2.9.2 The heating equipments as described in Clauses 9.3.10.2.1 and 9.3.10.2.2 (29.2.9.2 and 29.2.9.2.2) are generally used.

29.2.9.2.1 Hot Water Heated Coils
Central heating systems using hot water usually require not more than one or two rows of tubes in the direction of air flow, in order to produce the desired heating capacity. To achieve high efficiency without excessive water pressure drop through the coil, various circuit arrangements are used.

Generally, the resistance to the hot water flow through the heater should not exceed 4 kPa in low pressure hot water heating installations. In high pressure hot water installations, the resistance to the water flow will probably be determined by other factors, for example, the need to balance circuits.

The heaters should be served form hot water flow and return mains with sufficient connections to each row or bank of tubes or clauses to give uniform distribution of the heating medium.

The flow connections to the heater should generally be arranged at the lowest point of the heater, and the return connections at the highest, to aid venting. The expansion of the tubes when the heater is in operation should be considered and the necessary arrangements made to accommodate expansion and contraction.

Thermometer wells should be fitted in the pipes near the inlets and outlets of all air-heating coils so that the temperature drop through the heater can be readily observed.

29.2.9.2.2 Electric air heater
The air velocity through the heaters should be sufficient to permit the absorption of the rated output of the finned tube heaters within its range of safe temperatures and the exact velocity determined in conjunction with the manufacturers of the heater. Electrical load should be balanced across the three- phases of the electrical supply.

Where automatic temperature control is required the heater should be divided into a number of clauses dependent upon the degree of control to be effected.

Each clause of heater elements, which may be two rows of elements should have its own busbars and connection and be capable of withdrawal from the casing, thus enabling the elements to be cleaned or repaired whilst the remainder is in operation. Each clause should be capable of being isolated electrically before being withdrawn from the casing.

All heaters should be electrically interlocked with the fan motors, so that the electric heater will be switched off when the fan is stopped or when the air velocity is reduced to a level.
below that for which the heater has been designed.

The air velocity over the face of the heater is of particular importance in the design of electric air heaters, and the manufacturers should be given details of the maximum and minimum air velocities likely to occur.

With all electric air heaters, care should be taken to preclude the risk of fire under abnormal conditions of operation, by the use of a suitably positioned temperature sensitive trip of the manual reset type to cut off the electric supply.

29.2.10 Symbols, units, colour Code and identification of services

29.2.10.1 Units and symbols to be used in air conditioning, ventilation and refrigeration systems shall be in accordance with good practice.

29.2.10.2 Colour Code for identification of various items in air conditioning installations for easy interpretation and identification is advisable. This shall promote greater safety and lessen chances of error, confusion or inaction in times of emergency. Colour shade shall generally be in accordance with good practice.

29.2.10.3 Colour bands shall be 150mm wide, super-imposed on ground colour to distinguish type and condition of fluid. The spacing of bands shall not exceed 4.0m.

29.2.10.4 Further identification may also be carried out using lettering and marking the direction of flow.

29.2.10.5 Services identification

29.2.10.5.1 Pipe work services

29.2.10.5.1.1 The scheme of colour Code for painting of pipe work services for air conditioning installation shall be as indicated in Table 6.

29.2.10.5.1.2 In addition to the colour bands specified above, all pipe work shall be legibly marked with black or white letters to indicate the type of service and the direction of flow, identified as follows:

<table>
<thead>
<tr>
<th>High Temperature Hot Water</th>
<th>HTHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Temperature</td>
<td>MTHW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Services</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditioned Air</td>
<td>Red and Blue</td>
</tr>
<tr>
<td>Ward Air</td>
<td>Yellow</td>
</tr>
<tr>
<td>Fresh Air</td>
<td>Green</td>
</tr>
<tr>
<td>Exhaust/Extract/Recalculated Air</td>
<td>Grey</td>
</tr>
<tr>
<td>Foul Air</td>
<td>Brown</td>
</tr>
<tr>
<td>Dual Duct System Hot Supply Air</td>
<td>Red</td>
</tr>
<tr>
<td>Cold Supply Air</td>
<td>Blue</td>
</tr>
</tbody>
</table>

29.2.10.5.2 Duct work services

29.2.10.5.2.1 For duct work services and their insulation, colour triangles may be provided. The size of the triangle will depend on the size of the duct and viewing distance but the minimum size should not be less than 150mm length per side.

The colour for various duct work services shall be as given below:

<table>
<thead>
<tr>
<th>Services</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditioned Air</td>
<td>Red and Blue</td>
</tr>
<tr>
<td>Ward Air</td>
<td>Yellow</td>
</tr>
<tr>
<td>Fresh Air</td>
<td>Green</td>
</tr>
<tr>
<td>Exhaust/Extract/Recalculated Air</td>
<td>Grey</td>
</tr>
<tr>
<td>Foul Air</td>
<td>Brown</td>
</tr>
<tr>
<td>Dual Duct System Hot Supply Air</td>
<td>Red</td>
</tr>
<tr>
<td>Cold Supply Air</td>
<td>Blue</td>
</tr>
</tbody>
</table>

29.2.10.5.3 Value labels and charts

Each valve shall be provided with a label indicating the service being controlled, together with a reference number corresponding with that shown on the Valve Charts and ‘as fitted’ drawings. The labels shall be made from 3 ply (black/white/black) traffolyte material showing white letters and figures on a black background. Labels shall be tied to each valve with chromium plated linked chain.

29.2.11 Energy conservation, energy management, automatic controls and building management system
29.2.11.1 In the context of this Code, energy conservation signifies the optimum use of energy to operate the air conditioning, heating and ventilation system of a building.

<p>| Table 6: Scheme of colour Code of pipe work services for air conditioning installation |
| (Clause 29.2.10.5.1.1) |</p>
<table>
<thead>
<tr>
<th>(1)</th>
<th>Description (2)</th>
<th>Ground Colour (3)</th>
<th>Lettering Colour (4)</th>
<th>First Colour Band (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Cooling water</td>
<td>Sea green</td>
<td>Black</td>
<td>French blue</td>
</tr>
<tr>
<td>ii)</td>
<td>Chilled water</td>
<td>Sea green</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>iii)</td>
<td>Central heating below 60°C</td>
<td>Sea green</td>
<td>Black</td>
<td>Canary yellow</td>
</tr>
<tr>
<td>iv)</td>
<td>Central heating 60°C to 100°C</td>
<td>Sea green</td>
<td>Black</td>
<td>Dark violet</td>
</tr>
<tr>
<td>v)</td>
<td>Drain pipe</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>vi)</td>
<td>Vents</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>vii)</td>
<td>Valves and pipe line fittings</td>
<td>White</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>viii)</td>
<td>Belt guard</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>ix)</td>
<td>Machine bases, inertia bases and plinth</td>
<td>Charcoal grey</td>
<td>Black</td>
<td>Black</td>
</tr>
</tbody>
</table>

29.2.11.2 It is axiomatic that general standards of comfort or specific environmental requirements within the building should not be compromised in an endeavour to achieve lower consumption of energy. Similarly nothing in this Code overrides regulations related to health and safety.

29.2.11.3 Considerations for energy conservation and management

29.2.11.3.1 Energy targets
For the purpose of assessing energy conservation efficiency of one system design against another, or in an existing building, comparing one period of energy use against another, target consumptions may be established.

29.2.11.3.2 Demand targets
Energy demand is mainly determined by location of the building, its structure and the equipment installed within it. Demand targets are readily applied to designs for new buildings and are quoted as an ‘average rate’ of energy use (W/m²).

29.2.11.3.3 Consumption targets
The energy actually consumed in a building is determined by the manner in which the building and its services are used and is measured in units of energy (Wh/m²). Targets may be established according to varying climatic conditions and varying pattern of building use.
29.2.11.3.4 Air conditioning/ventilation

Some of the more important aspects of establishing energy conservation requirements for air conditioning and ventilation systems are given below.

29.2.11.3.5 The design of the system and its associated controls should take into account the following:

   a) the nature of the applicants;
   b) the type of construction of building;
   c) external and internal load patterns;
   d) the desired space conditions;
   e) permissible control limits;
   f) control methods for minimizing use of primary energy;
   g) opportunities for heat recovery;
   h) economic factors (including probable future cost and availability of fuel);
   i) opportunity for optimizing electrical installation and energy conservation by using thermal energy storage.

29.2.11.3.6 The operation of the system for the following conditions has to be considered when assessing the complete design:

   a) in hot season;
   b) in cold/dry season;
   c) in intermediate seasons;
   d) at night;
   e) at weekends; and
   f) restoration of power supply after intermittent failure.

29.2.11.3.7 Consideration should be given to changes in building load in the system design so that maximum operational efficiency is maintained under part load conditions. Similarly, the total system should be separated into smaller increments having similar load requirements so that each area can be separately controlled to maintain optimum operating conditions.

29.2.11.3.8 The temperature of heating or cooling media circulated within the system should be maintained at the level necessary to achieve the required output to match the prevailing load conditions with the minimum consumption of energy.

29.2.11.3.9 Energy recovery has to be maximized.

29.2.11.3.10 Operation and maintenance procedures have to be properly planned.

29.2.11.3.11 Equipment considerations

29.2.11.3.11.1 All equipment and components should be tested in accordance with the relevant Ghanaian Standards. Where no applicable standard exists, an agreed international or other standard and test procedure may be adopted.

29.2.11.3.11.2 The equipment suppliers should furnish, upon request, the energy input and output of the equipment, which should cover full and partial loads and standby conditions as required in order that the energy consumption can be assessed over the whole range of operating conditions.

29.2.11.3.11.3 Where components from more than one supplier are used in combination, for which published performance data do not exist, then the system designer should take the responsibility for ensuring that their combination leads to optimum energy use.

29.2.11.3.11.4 Equipment preventive maintenance schedule should be furnished along with all other required information.

29.2.11.4 Control system

The designer should aim at selecting the simplest system of control capable of producing the space conditions required. It is uneconomical to provide controls with a degree of accuracy greater than that required by the application. Consideration should be given to the provision of centralized monitoring and control, thus achieving optimum operation.

29.2.11.5 Automatic controls and building management system

29.2.11.5.1 Types of equipment

The basic components that are designed and, selected to work together to form a complete control system, together with their functions, are shown as follows:

<table>
<thead>
<tr>
<th>Element or Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
29.2.11.5.2 Sensing and measuring elements

29.2.11.5.2.1 Temperature elements

a) A bimetal element comprises two thin strips of dissimilar metals fused together and arranged as a straight, U-shaped or spiral element. The two metals have different coefficients of thermal expansion, so a change in temperature causes the element to bend and produce a change in position.

b) A rod and tube element is composed of a high expansion metal tube inside which is located a low expansion rod with one end fixed to the rear of the tube so that temperature changes cause the free end of the rod to move.

c) Sealed bellows element is evacuated of air and charged with a liquid, gas or vapour, which changes in pressure or volume as surrounding temperature changes, resulting in change of force or movement.

d) Remote bulb element consists of a sealed bellows or diaphragm to which a bulb or capsule is attached by means of capillary tubing, the entire system being filled with liquid, gas or vapour. Temperature changes at the bulb are communicated as pressure or volume changes through the capillary tube to the bellows or diaphragm.

e) Resistance temperature detectors (RTDs) are temperature sensors containing either a fine wire or a thin metallic element whose resistance increases with temperature and varies in a known manner. RTDs are characterized by their high degree of linearity, good sensitivity and excellent stability. RTDs are used with electronic controllers.

f) Thermocouple element comprises a junction between two dissimilar metals that generates a small voltage related to the temperature.
a) These devices have a hygroscopic organic polymer deposited on a water permeable substrate. The polymer film absorbs moisture until it is balanced with the ambient air. This causes a change in resistance or capacitance.

b) Resistance elements, as employed in electronic systems, consist usually of two interleaved grids of gold foil, each connected to a terminal and mounted on a thin slab of insulating plastic material with a coating of hygroscopic salt (lithium chloride) on the block. A conductive path between adjacent strips of foil is formed, and the high electric resistance of this circuit changes as the chemical film absorbs and releases moisture with changes in the relative humidity of surrounding air.

29.2.11.5.2.3 Pressure elements

a) Low-pressure measuring elements for low positive pressure or for vacuum conditions, for example, static pressure in an air duct, usually comprise a large slack diaphragm, or large flexible bellows. In one type of static pressure regulator, two bells are suspended from a lever into a tank of oil, so that positive pressure under one of the bells moves the bell and lever up (or down) to complete an electric circuit. The majority of these elements sense differential pressure, and when combined with pitot tubes, orifice plates, and venturi meters may be used to measure velocity, flow rate or liquid level.

b) High-pressure measuring elements, for pressure or vacuum measurements in the kPa range, are usually of bellows, diaphragm or Bourdon tube type. If one side of the element is left open to the atmosphere, the element will respond to pressure above or below atmospheric.

29.2.11.5.2.4 Special elements

a) Special elements for various measuring or detecting purposes are often necessary for complete control in air conditioning or ventilating systems, for example a ‘paddle-blade’ type of air flow switch may be interlocked with an electric heater battery to prevent battery from operating and overheating in the event of an air flow failure.

b) Other elements employed form time-to-time are measuring smoke density, carbon monoxide (for example in road traffic tunnels or underground car parks) and carbon dioxide, and for flame detection.

29.2.11.5.2.5 Controllers

Controlling elements normally regulate the application of either electrical or pneumatic energy. Controllers are mainly of three types: thermostat, humidistats and pressure controllers.

29.2.11.5.2.6 Thermostats

The following types of thermostats are in common use:

a) The room type responds to room air temperature and is designed for mounting on a wall.

b) The insertion thermostats responds to the temperature of air in a duct and are designed for mounting on the inside of a duct with its measuring element extending into the air stream.

c) The immersion type responds to the temperature of a fluid in a pipe or tank is designed for mounting on the outside of a pipe or tank with a fluid-tight connection to allow the measuring element to extend into the fluid.

d) The remote bulb thermostat is used where the point of temperature measurement is some distance from the desired thermostat location, which may often be in a central panel. A differential type employing two remote bulbs may be used to maintain a given temperature difference between two points.

e) The surface type is designed for mounting on a pipe or similar surface and measuring its temperature, or to give an approximate measurement of temperature of the fluid within the pipe.
f) The day/night room thermostat is arranged to control at a reduce temperature at night, and may be changed from day to night operation at a remote point by hand or time clock, or from a time switch built into the thermostat itself.

g) The heating/cooling thermostat can have its action reversed and, where required, its set points raised or lowered by remote control. This type of thermostat is used to actuate controlled devices, such as valves or dampers, that may regulate a heating medium at one time and cooling medium at another.

h) The multi-step thermostat is arranged to operate in two or more successive steps.

i) A master thermostat measures conditions at one point of another (sub-master) thermostat or controller.

29.2.11.5.2.7 Humidistats

Humidistats may be of the room or insertion type. For example, a sub-master room humidistat may be used with an outdoor master thermostat to reduce humidity in cold weather and prevent condensation on windows. A wet-bulb thermostat is often used for accurate humidity control, working in conjunction with a dry bulb controller.

29.2.11.5.2.8 Pressure controllers

Pressure or static pressure controllers are made for mounting directly on a pipe or duct. The controller may also be mounted remotely on a panel.

29.2.11.5.2.9 Controlled devices

29.2.11.5.2.9.1 Automatic control valves

An automatic control valve consists of a valve body to control the flow of fluid passing through it by use of a variable orifice that is positioned by an operator in response to signals from the controller. The fluid handled is generally steam or water, and the operator is usually of the electric motor or pneumatic actuator type. As 75 percent or more of all air conditioning and mechanical ventilation systems utilize a valve of some sort as the final control element, proper control valve selection is one of the most important factors in attaining good system performance.

Following are the details of various valve types and valve operators:

a) Valve types – The main type and their characteristics are summarized below:

1) Single seated valves are designed for tight shut-off.

2) Double seated valves are designed so that the fluid pressure on the two discs is essential balanced, reducing the power required to operate; this type of valve does not provide a tight shut-off.

3) Pippilot operated valves utilize the pressure difference between upstream and downstream sides to act upon a diaphragm or piston to move the valve, and are usually single seated, for two piston applications only, and used where large forces are required for valve operation.

4) Low flow valves may be as small as 3 mm port size and are used for accurate control of low flow rates.

5) Three way mixing valves have two inlets and one outlet, and operate to vary the proportion of fluid entering each of the two inlets.

6) Three way diverting valves have one inlet and two outlets and operate to divert or proportion the inlet flow to either of the two outlets.

7) Two way modulating valves have one inlet and one outlet and operate to modulate or proportion the flow through the heat exchange equipment.

8) Butterfly valves comprise a heavy ring enclosing a disc that rotates on an axis at or near its centre and may be used for shut-off where low differential pressures exist.
9) Special multi-port valves for various types of modulating/sequences operation are available for control of both hot and chilled water to three and four pipe fan coil and induction unit systems.

b) Valve operators – Valve operators usually comprise an electric solenoid, electric motor, or pneumatic actuator, brief details of which are given below:

1) A solenoid is a magnetic coil that operates a movable plunger to provide two-piston operation.

2) An electric motor is arranged to operate the valve stem through a gear train and linkage. Various types are available for different applications, such as:

i) An unidirectional motor is used for two position operation, the valve opening during one half revolution of the output shaft and closing during the next half revolution.

ii) A spring return motor for two position control operation is energized electrically, driven to one position, and held there until the circuit is broken, when the spring returns the valves to its normal position.

iii) A reversible motor is used for floating or proportional operation and can run in either direction and stop in any position.

3) A pneumatic actuator usually comprises a spring opposed flexible diaphragm or bellows connected to the valve stem, so that an increase in air pressure acts on the diaphragm or bellows to move the valve stem and compress the spring. When the air pressure is removed the spring will return the operator to its normal position.

29.2.11.5.2.9.2 Automatic control dampers

Control dampers are designed to control the flow of air in a ductwork system in much the same as an automatic valve operates in a fluid circuit, that is by varying the resistance to flow. Following are the details of various damper valves and damper operators:

a) Damper valves

1) The single blade damper is generally restricted to small sizes since it does not provide accurate control. When fitted in circular ductwork it may be referred to as a butterfly damper.

2) A multi-leaf damper is two or more blades linked together, which may be:

   i) parallel action multi-leaf damper, having its blades linked so that when operated they all rotate in the same direction;

   ii) An opposed action multi-leaf damper, having adjacent blades linked to rotate in opposite directions when operated.

b) Damper operators

These may be electric motors of the unidirectional, spring return or reversible type fitted with suitable linkage mechanisms, or may be pneumatic actuators of a type designed for damper operation.

29.2.11.5.2.9.3 Centralized control/monitoring equipment

The centralized control system, which is shown diagrammatically in Fig.1, comprises three main parts: the remote location equipment, the transmission links and the central equipment.

29.2.11.5.2.9.4 Remote location equipment

This includes:

a) input devices or sensors, which measure the condition of a variable;

b) signal conditioning devices, which convert the sensor signal to a type compatible with the requirements of the remote panel, transmission system, or the central equipment;

c) output devices, which provide a means for converting a command instruction, appearing at the remote panel, into a signal suitable for performing an operational function on external equipment; and

d) remote data collection panels or remote enclosure, which act as termination points for the remote ends of the transmission links and for connection to the remote input and output devices.

29.2.11.5.2.9.5 Transmission links
The transmission links provide the means for communication between the central equipment and the remote data collection panel and may be classified according to a number of variables, which include:

a) medium (wires or cables, telephone lines, micro-wave);
   b) transmission mode (one direction only, one direction at time, etc);
   c) data sequence (series for 2-wire, parallel for multi-conductor etc);
   d) wire or cable types;
   e) signal types; and
   f) message format.

Other considerations include the physical arrangement of the transmission system, security and supervisory aspect.

29.2.11.5.2.9.6 Central equipment

This may comprise:

a) An interface, which provides a connection point and the signal conversion between the central processor and transmission links;

b) The central processor, which is the collection of equipment at the central control room containing the logic for management of the centralized control and monitoring system; the processor has the means to receive, transmit and present information, with the ability to process all data in an orderly fashion, and may or may not include a computer;

c) Peripheral devices such as typewriters, printers, displays (digital type, projectors, or cathode ray tubes, etc).

29.2.11.5.3 Selection factors

29.2.11.5.3.1 Common factors

There are a number of factors to be considered in the selection of almost all control system components. These common factors include:

a) supply and working electricity voltage, phase, frequency and number of wires;
   b) maximum and/or minimum temperatures, humidities or pressures to which components may be subjected;
   c) restrictions or location, mounting positions etc., or possible problems due to duct, vibration etc;
   d) dimensions and mass;
   e) finish and type of enclosure; and required accessories or fittings.
   f) required accessories or fittings.

Note – These common factors, should only be used as a general guide, and control manufacturers should be consulted in establishing exact requirements.

29.2.11.5.4 Sensing/measuring elements

Sensing and measuring elements frequently form an integral part of a controller and the selection factors to be considered for this arrangement may be as given in Clause 29.2.11.5.3.1. However, a sensor may be designed and arranged for operation with a remote controller and other components. In that case some of the more important selection factors for temperature elements, for example, may be as follows:

a) control operations, for example reverse or direct-acting;
   b) sensing range, adjustable or non-adjustable;
   c) provision for air filter;
   d) pressure output;
   e) provision for branch pressure indication;
   f) application, for example room, duct or immersion in pipeline;
   g) application, for example room, duct immersion in pipeline;
   h) electronic;
   i) function, for example for primary or secondary control;
   j) temperature range;
   k) authority range of throttling range adjustment;
   l) nominal resistance and sensitivity; and
   m) provision for temperature indication.
Fig. 1 System Connectivity Arrangement for Building Management System
29.2.12 Inspection, commissioning and testing

29.2.12.1 Inspection, commissioning and testing should be carried out meticulously if a satisfactory installation is to be handed over to the client. It should be ensured that these are carried out thoroughly and all results are properly documented. It is recommended that the whole commissioning procedure should be under the guidance and control of a single authority, to be identified by the client.

29.2.12.2 Inspection and testing

All equipment and components supplied may be subjected to inspection and tests during manufacture, erection/installation and after completion. No tolerances at the time of inspection shall be allowed other than those specified or permitted in the relevant approved standards, unless otherwise stated. Approval at the time of inspection shall not be construed as acceptance unless the equipment proves satisfactory in service after erection.

High pressure air duct systems should also be tested in accordance with the procedures.

29.2.12.2.1 Inspection and testing at works

The air conditioning system will consist of various items of equipment produced by various manufacturers. Every manufacturer should give facilities for the inspection of their equipment during manufacturing and on completion, as specified.

29.2.12.2.2 Inspection and testing on site

Prior to commissioning, testing, adjusting and balancing, preliminary checks and charging of the complete system should be carried out. It is important that all water systems should have been thoroughly flushed through and hydraulically pressure tested to 1.5 times the working pressure for a period of not less than 8 hours.

29.2.12.3 Commissioning, testing, adjusting and balancing

29.2.12.3.1 Basic considerations

29.2.12.3.1.1 The basic considerations are:

a) to test to determine quantitative performance of equipment;

b) to adjust to regulate for specified fluid flow rates and air patterns at terminal equipment (for example reduce fan speed, throttling etc); and

c) to balance the proportion within distribution systems (sub mains, branches and terminals) in accordance with design quantities.

29.2.12.3.2 System testing, adjusting and balancing

29.2.12.3.2.1 Refrigeration plant

The refrigeration plant may be tested for the following:

a) adjusting water flow rate through chiller and condenser by use of balancing valves;

b) ascertaining the capacity by measurement of water flow rate and temperature of water at inlet and outlet of chilling machine;

c) computation of power consumption;

d) verifying operating noise level as per manufacturer instructions.

29.2.12.3.2.2 Air system

29.2.12.3.2.2.1 Air handlers performance

The testing, adjusting and balancing procedure shall establish the right selection and performance of the air handling units with the following results:

a) air-in dry-bulb and wet-bulb temperature;
b) air-out dry-bulb and wet-bulb temperature;  
c) leaving air dew point temperature;  
d) fan air volume;  
e) fan air outlet velocity;  
f) fan static pressure;  
g) fan power consumption;  
h) fan speed; and  
i) check for zero water retention in the condensate drain pan.

29.2.12.3.2.2 Air distribution
Both supply and return air distribution for each air handling unit and for areas served by the air handling unit shall be determined and adjusted as necessary to provide design air quantities. It shall cover balancing of air through main and branch ducts.

29.2.12.3.2.3 Hydronic system
The hydronic system shall involve the checking and balancing of all water pumps, piping network (main and branches), heat exchange equipment like cooling and heating coils, condensers, chillers and cooling towers in order to provide design water flows.

The essential preparatory work, shall be done by the air conditioning contractor prior to actual testing, adjusting and balancing and shall ensure the following:

a) Hydronic system is free of leaks, hydrostatically tested and is thoroughly cleaned, flushed and refilled.
b) Hydronic system is vented.
c) Check pumps operation for proper rotation and motor current drawn etc.
d) Confirm that provisions for tabulation of measurements (temperature, pressure and flows) have been made.
e) Open all shut-off valves and automatic control valves to provide full flow through coils. Set all balancing valves in the preset position, if these values are known. If not, shut all riser balancing valves except the one intended to be balanced first.

Balancing work for both chilled water system and condenser water system shall be carried out in a professional manner and test reports in the specified format shall be prepared.

29.2.12.4 Controls
Since most of the control equipment used for air conditioning system is factory calibrated, hence physical verification before installation shall be carried out. In addition, manufacturer’s instructions should be followed for site calibration, if any:

29.2.12.5 Noise and sound control
Measurements should be taken with a sound level meter either using the ‘A’ weighing scale or to draw up a noise criteria curve. Measurements should be taken in the following locations:

a) plant rooms;  
b) occupied rooms adjacent to plant rooms;  
c) outside plant rooms facing air intakes and exhausts and condenser discharge, to assess possible nuisance to adjacent occupied areas;  
d) in the space served by the first grille or diffuser after a fan outlet;  
e) in at least two of the spaces served by fan coil units or high velocity system terminal units (where applicable);  
f) in any space; and  
g) air handling unit (AHU) rooms and adjoining areas.

29.2.12.6 Handover procedure
Handover documentation should contain all information that the user needs to enable the installation and equipment to be efficiently and economically operated and maintained. It should also provide a record of the outcome of any site testing, balancing and regulation carried out prior to handover.

Handover documentation should include the following:

a) description of the installation, including simplified line flow and balance diagrams for the complete installation;  
b) as-built installation drawings;  
c) operation and maintenance instructions for equipment, manufacturer’s service maintenance manuals, manufacture’s spare parts list and spares ordering instructions;  
d) schedules of electrical equipment;  
e) schedules of mechanical equipment;  
f) test results and test certificates as called for under the contract including any insurance or statutory inspection authority certificate;  
g) copies of guarantee certificates for plant and equipment; and  
h) list of keys, tools and spare parts that are handed over.
29.3 VENTILATION
29.3.1 General

29.3.1.1 Scope.
This part shall govern the ventilation of spaces within a building intended to be occupied. Mechanical exhaust systems, including exhaust systems serving cooking appliances; hazardous exhaust systems; dust, stock and refuse conveyor systems; sub-slab soil exhaust systems; smoke control systems; energy recovery ventilation systems and other systems shall comply with this Code.

29.3.1.2 Ventilation required.
Every occupied space shall be ventilated by natural means in accordance with Clause 29.3.2 or by mechanical means in accordance with Clause 29.3.3. Ambulatory care facilities and Group I-2 occupancies shall be ventilated by mechanical means in accordance with Clause 29.3.7.

29.3.1.3 When required.
Ventilation shall be provided during the periods that the room or space is occupied.

29.3.1.4 Intake opening location.
Air intake openings shall comply with all of the following:

1. Intake openings shall be located not less than 3048 mm (10 feet) from plot lines or buildings on the same plot.

2. Mechanical and gravity outdoor air intake openings shall be located not less than 3048 mm (10 feet) horizontally from any hazardous or noxious contaminant source, such as vents, streets, alleys, parking plots and loading docks, except as specified in Item 3 or this Code. Outdoor air intake openings shall be permitted to be located less than 3048 mm (10 feet) horizontally from streets, alleys, parking plots and loading docks provided that the openings are located not less than 7620 mm (25 feet) vertically above such locations. Where openings front on a street or public way, the distance shall be measured from the closest edge of the street or public way.

3. Intake openings shall be located not less than 914 mm (3 feet) below contaminant sources where such sources are located within 3048 mm (10 feet) of the opening.

4. Intake openings on structures in flood hazard areas shall be at or above the elevation required by the In this Code for utilities and attendant equipment.

29.3.1.5 Intake opening protection.
Air intake openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles. Openings in louvers, grilles and screens shall be sized in accordance with Table 29.3.1.5, and shall be protected against local weather conditions. Outdoor air intake openings located in exterior walls shall meet the provisions for exterior wall opening protectives in accordance with the Ghana Building Code.

<table>
<thead>
<tr>
<th>OUTDOOR OPENING TYPE</th>
<th>MINIMUM AND MAXIMUM OPENING SIZES IN LOUVERS, GRILLES AND SCREENS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake openings in residential occupancies</td>
<td>Not $&lt; \frac{1}{4}$ inch and not $&gt; \frac{1}{2}$ inch</td>
</tr>
<tr>
<td>Intake openings in other than residential occupancies</td>
<td>$&gt; \frac{1}{4}$ inch and not $&gt; 1$ inch</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. For rectangular openings, the table requirements apply to the shortest side. For round openings, the table requirements apply to the diameter.
For square openings, the table requirements apply to any side.

29.3.1.6 Contaminant sources.
Stationary local sources producing airborne particulates, heat, odors, fumes, spray, vapours, smoke or gases in such quantities as to be irritating or injurious to health shall be provided with an exhaust system or a means of collection and removal of the contaminants. Such exhaust shall discharge directly to an approved location at the exterior of the building.

29.3.2 Natural Ventilation

29.3.2.1 Natural ventilation.
Natural ventilation of an occupied space shall be through windows, doors, louvers or other openings to the outdoors. The operating mechanism for such openings shall be provided with ready access so that the openings are readily controllable by the building occupants.

29.3.2.2 Ventilation area required.
The minimum openable area to the outdoors shall be 4 percent of the floor area being ventilated.

29.3.2.3 Adjoining spaces.
Where rooms and spaces without openings to the outdoors are ventilated through an adjoining room, the opening to the adjoining rooms shall be unobstructed and shall have an area not less than 8 percent of the floor area of the interior room or space, but not less than 2.3 m² (25 square feet). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

Exception: Exterior openings required for ventilation shall be permitted to open into a thermally isolated sunroom addition or patio cover, provided that the openable area between the sunroom addition or patio cover and the interior room has an area of not less than 8 percent of the floor area of the interior room or space, but not less than 1.86 m² (20 square feet). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

29.3.2.4 Openings below grade.
Where openings below grade provide required natural ventilation, the outdoor horizontal clear space measured perpendicular to the opening shall be one and one-half times the depth of the opening. The depth of the opening shall be measured from the average adjoining ground level to the bottom of the opening.

29.3.3 Mechanical Ventilation

29.3.3.1 Ventilation system.
Mechanical ventilation shall be provided by a method of supply air and return or exhaust air except that mechanical ventilation air requirements for Group R-2, R-3 and R-4 occupancies three stories and less in height above grade plane shall be provided by an exhaust system, supply system or combination thereof. The amount of supply air shall be approximately equal to the amount of return and exhaust air. The system shall not be prohibited from producing negative or positive pressure. The system to convey ventilation air shall be designed and installed in accordance with this Code.

29.3.3.2 Outdoor air required.
The minimum outdoor airflow rate shall be determined in accordance with Clause 29.3.3.3.

Exception: Where the registered design professional demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation determined in accordance with Clause 29.3.3.3, the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design.

29.3.3.2.1 Recirculation of air.
The outdoor air required by Clause 29.3.3.3 shall not be recirculated. Air in excess of that required by Clause 29.3.3.3 shall not be prohibited from being recirculated as a component of supply air to building spaces, except that:

1. Ventilation air shall not be recirculated from one dwelling to another or to dissimilar occupancies.

2. Supply air to a swimming pool and associated deck areas shall not be recirculated unless such air is dehumidified to maintain the relative humidity of the area at 60
percent or less. Air from this area shall not be recirculated to other spaces where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces.

3. Where mechanical exhaust is required by Note b in Table 29.3.3.3.1.1, recirculation of air from such spaces shall be prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited. Where recirculation of air is prohibited, all air supplied to such spaces shall be exhausted, including any air in excess of that required by Table 29.3.3.3.1.1.

4. Where mechanical exhaust is required by Note g in Table 29.3.3.3.1.1, mechanical exhaust is required and recirculation from such spaces is prohibited where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces. Recirculation of air that is contained completely within such spaces shall not be prohibited.

29.3.3.2.2 Transfer air.

Except where recirculation from such spaces is prohibited by Table 29.3.3.3.1.1, air transferred from occupiable spaces is not prohibited from serving as makeup air for required exhaust systems in such spaces as kitchens, baths, toilet rooms, elevators and smoking lounges. The amount of transfer air and exhaust air shall be sufficient to provide the flow rates as specified in Clause 29.3.3.3.1.1. The required outdoor airflow rates specified in Table 29.3.3.3.1.1 shall be introduced directly into such spaces or into the occupied spaces from which air is transferred or a combination of both.

29.3.3 Outdoor air and local exhaust airflow rates.

Group R-2, R-3 and R-4 occupancies three stories and less in height above grade plane shall be provided with outdoor air and local exhaust in accordance with Clause 29.3.3.3.2. Other buildings intended to be occupied shall be provided with outdoor air and local exhaust in accordance with Clause 29.3.3.3.1.
### TABLE 29.3.3.1.1
MINIMUM VENTILATION RATES

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>OCCUPANT DENSITY #/1000 FT²</th>
<th>PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, Rₚ CFM/PERSON</th>
<th>AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, Rₚ CFM/FT²</th>
<th>EXHAUST AIRFLOW RATE CFM/FT²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correctional facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Booking/waiting</td>
<td>50</td>
<td>7.5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Cells</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without plumbing fixtures</td>
<td>25</td>
<td>5</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>with plumbing fixtures</td>
<td>25</td>
<td>5</td>
<td>0.12</td>
<td>1.0</td>
</tr>
<tr>
<td>Day room</td>
<td>30</td>
<td>5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Dining halls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(see “Food and beverage service”)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guard stations</td>
<td>15</td>
<td>5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Dry cleaners, laundries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coin-operated dry cleaner</td>
<td>20</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coin-operated laundries</td>
<td>20</td>
<td>7.5</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Commercial dry cleaner</td>
<td>30</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial laundry</td>
<td>10</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage, pick up</td>
<td>30</td>
<td>7.5</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art classroom</td>
<td>20</td>
<td>10</td>
<td>0.18</td>
<td>0.7</td>
</tr>
<tr>
<td>Auditoriums</td>
<td>150</td>
<td>5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Classrooms (ages 5-8)</td>
<td>25</td>
<td>10</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Classrooms (age 9 plus)</td>
<td>35</td>
<td>10</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Computer lab</td>
<td>25</td>
<td>10</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Corridors (see Public spaces*)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day care (through age 4)</td>
<td>25</td>
<td>10</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Lecture classroom</td>
<td>65</td>
<td>7.5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Lecture hall (fixed seats)</td>
<td>150</td>
<td>7.5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Locker/dressing rooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(see “Clothing storage”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Media center</td>
<td>25</td>
<td>10</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Multiuse assembly</td>
<td>100</td>
<td>7.5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Music/theater/dance</td>
<td>35</td>
<td>10</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Science laboratories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(see “Educational spaces”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

² a

This table outlines the minimum ventilation rates for various occupancy classifications, including correctional facilities, dry cleaners and laundries, education, and more, with specific details on occupant density, airflow rates, and exhaust airflow rates.
<table>
<thead>
<tr>
<th>Occupancy Classification</th>
<th>Occupancy Density #/1000 FT²</th>
<th>People Outdoor Airflow Rate in Breathing Zone, Rp CFM/Person</th>
<th>Area Outdoor Airflow Rate in Breathing Zone, Ra CFM/FT²</th>
<th>Exhaust Airflow Rate CFM/FT²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hotels, motels, resorts and dormitories</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathrooms/toilet—private</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bedroom/living room</td>
<td>10</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Conference/meeting</td>
<td>50</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Dormitory sleeping areas</td>
<td>20</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Gambling casinos</td>
<td>120</td>
<td>7.5</td>
<td>0.18</td>
<td>—</td>
</tr>
<tr>
<td>Lobbies/prefunction</td>
<td>30</td>
<td>7.5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Multipurpose assembly</td>
<td>120</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td><strong>Offices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference rooms</td>
<td>50</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Main entry lobbies</td>
<td>10</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Office spaces</td>
<td>5</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Reception areas</td>
<td>30</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Telephone/data entry</td>
<td>60</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td><strong>Private dwellings, single and multiple</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garages, common for multiple units</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.75</td>
</tr>
<tr>
<td>Kitchens</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>25/100</td>
</tr>
<tr>
<td>Living areas d</td>
<td></td>
<td></td>
<td>0.35 ACH but not less than 15 cfm/person</td>
<td></td>
</tr>
<tr>
<td>Toilet rooms and bathrooms</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>20/50</td>
</tr>
<tr>
<td><strong>Public spaces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corridors</td>
<td>—</td>
<td>—</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Courtrooms</td>
<td>70</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
</tbody>
</table>

(continued)

*(TABLE 29.3.3.1.1—continued)
MINIMUM VENTILATION RATES*
### TABLE 29.3.3.1.1—continued

#### MINIMUM VENTILATION RATES

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>OCCUPANT DENSITY #/1000 FT&lt;sup&gt;2&lt;/sup&gt;</th>
<th>PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R&lt;sub&gt;p&lt;/sub&gt; CFM/PERSON</th>
<th>AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R&lt;sub&gt;a&lt;/sub&gt; CFM/FT&lt;sup&gt;2&lt;/sup&gt;</th>
<th>EXHAUST AIRFLOW RATE CFM/FT&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty shops</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automotive motor-fuel b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dispensing stations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barber</td>
<td>25</td>
<td>7.5</td>
<td>0.06</td>
<td>0.5</td>
</tr>
<tr>
<td>Beauty salons b</td>
<td>25</td>
<td>20</td>
<td>0.12</td>
<td>0.6</td>
</tr>
<tr>
<td>Nail salons b, h</td>
<td>25</td>
<td>20</td>
<td>0.12</td>
<td>0.6</td>
</tr>
<tr>
<td>Embalming room b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pet shops (animal areas) b</td>
<td>10</td>
<td>7.5</td>
<td>0.18</td>
<td>0.9</td>
</tr>
<tr>
<td>Supermarkets</td>
<td>8</td>
<td>7.5</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Sports and amusement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bowling alleys (seating areas)</td>
<td>40</td>
<td>10</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Disco/dance floors</td>
<td>100</td>
<td>20</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Game arcades</td>
<td>20</td>
<td>7.5</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Gym, stadium, arena (play area)</td>
<td>7</td>
<td>20</td>
<td>0.18</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
### TABLE 29.3.3.1.1—continued
MINIMUM VENTILATION RATES

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>OCCUPANT DENSITY #/1000 FT$^2$</th>
<th>PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, CFM/PERSON</th>
<th>AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, CFM/FT$^2$</th>
<th>EXHAUST AIRFLOW RATE CFM/FT$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workrooms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank vaults/safe deposit</td>
<td>5</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Computer (without printing)</td>
<td>4</td>
<td>5</td>
<td>0.06</td>
<td>—</td>
</tr>
<tr>
<td>Copy, printing rooms</td>
<td>4</td>
<td>5</td>
<td>0.06</td>
<td>0.5</td>
</tr>
<tr>
<td>Darkrooms</td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Meat processing</td>
<td>10</td>
<td>15</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pharmacy (prep. area)</td>
<td>10</td>
<td>5</td>
<td>0.18</td>
<td>—</td>
</tr>
<tr>
<td>Photo studios</td>
<td>10</td>
<td>5</td>
<td>0.12</td>
<td>—</td>
</tr>
</tbody>
</table>

Note:

For SI: 1 cubic foot per minute = 0.0004719 m$^3$/s, 1 ton = 908 kg, 1 cubic foot per minute per square foot = 0.00508 m$^3$/s • m$^2$.

1°F = [(°F - 32)/1.8] • °C = 28.3 °C.

1 square foot = 0.0929 m$^2$.

a. Based on net occupiable floor area.

b. Mechanical exhaust required and the recirculation of air from such spaces is prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Clause 29.3.3.2.1, Item 3).

c. Spaces unheated or maintained below 50°F are not covered by these requirements unless the occupancy is continuous.

d. Ventilation systems in enclosed parking garages shall comply with Clause 29.3.4.

e. Rates are per water closet or urinal. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.
f. Rates are per room unless otherwise indicated. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

g. Mechanical exhaust is required and recirculation from such spaces is prohibited except that recirculation shall be permitted where the resulting supply airstream consists of not more than 10 percent air recirculated from these spaces. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Clause 29.3.3.2, Items 2 and 4).

h. For nail salons, each manicure and pedicure station shall be provided with a source capture system capable of exhausting not less than 50 cfm per station. Exhaust inlets shall be located in accordance with this Code. Where one or more required source capture systems operate continuously during occupancy, the exhaust rate from such systems shall be permitted to be applied to the exhaust flow rate required by Table 4.3.3.1.1 for the nail salon.

### Zone outdoor airflow.

The minimum outdoor airflow required to be supplied to each zone shall be determined as a function of occupancy classification and space air distribution effectiveness in accordance with Clauses 29.3.3.3.1.1.1 through 29.3.3.3.1.1.3.

#### 29.3.3.3.1.1.1 Breathing zone outdoor airflow.

The outdoor airflow rate required in the breathing zone ($V_{bz}$) of the occupiable space or spaces in a zone shall be determined in accordance with Equation 29.3-1.

$$V_{bz} = R_p P_z + R_a A_z$$  \hspace{1cm} (Equation 29.3-1)

where:

- $A_z =$ Zone floor area: the net occupiable floor area of the space or spaces in the zone.
- $P_z =$ Zone population: the number of people in the space or spaces in the zone.
- $R_p =$ airflow rate required per person from Table 4.3.3.1.1.
- $R_a =$ rate required per unit area from Table 4.3.3.1.1.

#### 29.3.3.3.1.1.2 Zone air distribution effectiveness.

The zone air distribution effectiveness ($E_z$) shall be determined using Table 29.3.3.3.1.1.2.

#### TABLE 29.3.3.3.1.1.2

<table>
<thead>
<tr>
<th>AIR DISTRIBUTION CONFIGURATION</th>
<th>$E_z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling or floor supply of cool air</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceiling or floor supply of warm air and floor return</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceiling supply of warm air and ceiling return</td>
<td>0.8</td>
</tr>
<tr>
<td>Floor supply of warm air and ceiling return</td>
<td>0.7</td>
</tr>
<tr>
<td>Makeup air drawn in on the opposite side of the room from the exhaust or return</td>
<td>0.8</td>
</tr>
<tr>
<td>Makeup air drawn in near to the exhaust or return location</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note:
For SI: 1 foot = 304.8 mm, 1 foot per minute = 0.00506 m/s. °C = [(°F) – 32] / 1.8.

a. "Cool air" is air cooler than space temperature.
b. "Warm air" is air warmer than space temperature.
c. "Ceiling" includes any point above the breathing zone.
d. "Floor" includes any point below the breathing zone.
e. Zone air distribution effectiveness of 1.2 shall be permitted for systems with a floor supply of cool air and ceiling return, provided that low-velocity displacement ventilation achieves unidirectional flow and thermal stratification.
f. Zone air distribution effectiveness of 1.0 shall be permitted for systems with a ceiling supply of warm air, provided that supply air temperature is less than 15°F above space temperature and that the foot-per-minute supply air jet reaches to within $\frac{1}{2}$ feet of floor level.

#### 29.3.3.3.1.1.3 Zone outdoor airflow.

The zone outdoor airflow rate ($V_{oz}$), shall be determined in accordance with Equation 29.3-2.

$$V_{oz} = \frac{V_{bz}}{E_z}$$  \hspace{1cm} (Equation 29.3-2)
29.3.3.1.1.2 System outdoor airflow.
The outdoor air required to be supplied by each ventilation system shall be determined in accordance with Clauses 29.3.3.1.1.2.1 through 29.3.3.1.1.2.3.4 as a function of system type and zone outdoor airflow rates.

29.3.3.1.1.2.1 Single zone systems.
Where one air handler supplies a mixture of outdoor air and recirculated return air to only one zone, the system outdoor air intake flow rate ($V_{ot}$) shall be determined in accordance with Equation 29.3-3.

\[
V_{ot} = V_{oz} \tag{Equation 29.3-3}
\]

29.3.3.1.1.2.2 100-percent outdoor air systems.
Where one air handler supplies only outdoor air to one or more zones, the system outdoor air intake flow rate ($V_{ot}$) shall be determined using Equation 29.3-4.

\[
V_{ot} = \frac{V_{oz}}{\text{all zones}} \tag{Equation 29.3-4}
\]

29.3.3.1.1.2.3 Multiple zone recirculating systems.
Where one air handler supplies a mixture of outdoor air and recirculated return air to more than one zone, the system outdoor air intake flow rate ($V_{ot}$) shall be determined in accordance with Clauses 29.3.3.1.1.2.3.1 through 29.3.3.1.1.2.3.4.

29.3.3.1.1.2.3.1 Primary outdoor air fraction.
The primary outdoor air fraction ($Z_p$) shall be determined for each zone in accordance with Equation 29.3-5.

\[
Z_p = \frac{V_{oz}}{V_{pz}} \tag{Equation 29.3-5}
\]

$D$ = Occupant diversity: the ratio of the system population to the sum of the zone populations, determined in accordance with Equation 4-7.

where:

\[
V_{pz} = \text{Primary airflow: The airflow rate supplied to the zone from the air handling unit at which the outdoor air intake is located. It includes outdoor intake air and recirculated air from that air-handling unit but does not include air transferred or air recirculated to the zone by other means. For design purposes, } V_{pz}
\]

$V_{pz}$ shall be the zone design primary airflow rate, except for zones with variable air volume supply and $V_{pz}$ shall be the lowest expected primary airflow rate to the zone when it is fully occupied.

29.3.3.1.1.2.3.2 System ventilation efficiency.
The system ventilation efficiency ($E_v$) shall be determined using Table 29.3.3.1.1.2.3.2.

<table>
<thead>
<tr>
<th>Max ($Z_p$)</th>
<th>$E_v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>1</td>
</tr>
<tr>
<td>0.25</td>
<td>0.9</td>
</tr>
<tr>
<td>0.35</td>
<td>0.8</td>
</tr>
<tr>
<td>0.45</td>
<td>0.7</td>
</tr>
<tr>
<td>0.55</td>
<td>0.6</td>
</tr>
<tr>
<td>0.65</td>
<td>0.5</td>
</tr>
<tr>
<td>0.75</td>
<td>0.4</td>
</tr>
<tr>
<td>$&gt; 0.75$</td>
<td>0.3</td>
</tr>
</tbody>
</table>

a. Max ($Z_p$) is the largest value of $Z_p$ calculated using Equation 4-5 among all the zones served by the system.
b. Interpolating between table values shall be permitted.

29.3.3.1.1.2.3.3 Uncorrected outdoor air intake.
The uncorrected outdoor air intake flow rate ($V_{ou}$) shall be determined in accordance with Equation 4-6.

\[
V_{ou} = D_{all zones} R_{all zones} \cdot R_{pz} A_z \tag{Equation 29.3-6}
\]

where:
where:

- \( P_s \) = System population: The total number of occupants in the area served by the system. For design purposes, \( P_s \) shall be the maximum number of occupants expected to be concurrently in all zones served by the system.

29.3.3.3.1.2.3.4 Outdoor air intake flow rate.
The outdoor air intake flow rate \( V_{oi} \) shall be determined in accordance with Equation 29.3-8.

\[
V_{oi} = \frac{V_{of}}{E_v} \quad \text{(Equation 29.3-8)}
\]

29.3.3.3.2 Exhaust ventilation.
Exhaust airflow rate shall be provided in accordance with the requirements of Table 29.3.3.3.1.1. Outdoor air introduced into a space by an exhaust system shall be considered as contributing to the outdoor airflow required by Table 29.3.3.3.1.1.

29.3.3.3.3.1.3 System operation.
The minimum flow rate of outdoor air that the ventilation system must be capable of supplying during its operation shall be permitted to be based on the rate per person indicated in Table 4.3.3.1.1 and the actual number of occupants present.

29.3.3.3.1.4 Variable air volume system control.
Variable air volume air distribution systems, other than those designed to supply only 100-percent outdoor air, shall be provided with controls to regulate the flow of outdoor air. Such control system shall be designed to maintain the flow rate of outdoor air at a rate of not less than that required by Clause 29.3.3.3 over the entire range of supply air operating rates.

29.3.3.3.1.5 Balancing.
The ventilation air distribution system shall be provided with means to adjust the system to achieve not less than the minimum ventilation airflow rate as required by Clauses 29.3.3.3 and 29.3.3.3.1.2. Ventilation systems shall be balanced by an approved method. Such balancing shall verify that the ventilation system is capable of supplying and exhausting the airflow rates required by Clauses 29.3.3.3 and 29.3.3.3.1.2.

29.3.3.3.2 Group R-2, R-3 and R-4 occupancies, three stories and less.
The design of local exhaust systems and ventilation systems for outdoor air in Group R-2, R-3 and R-4 occupancies three stories and less in height above grade plane shall comply with Clauses 29.3.3.3.2.1 through 29.3.3.3.2.5.

29.3.3.3.2.1 Outdoor air for dwelling units.
An outdoor air ventilation system consisting of a mechanical exhaust system, supply system or combination thereof shall be installed for each dwelling unit. Local exhaust or supply systems, including outdoor air ducts connected to the return side of an air handler, are permitted to serve as such a system. The outdoor air ventilation system shall be designed to provide the required rate of outdoor air continuously during the period that the building is occupied. The minimum continuous outdoor airflow rate shall be determined in accordance with Equation 29.3-9.

\[
Q_{OA} = 0.01A_{floor} + 7.5(N_{br} + 1) \quad \text{(Equation 29.3-9)}
\]

where:

- \( Q_{OA} \) = outdoor airflow rate, cfm
- \( A_{floor} \) = floor area, ft\(^2\)
- \( N_{br} \) = number of bedrooms; not to be less than one

**Exception:** The outdoor air ventilation system is not required to operate continuously where the system has controls that enable operation for not less than 1 hour of each 4-hour period. The average outdoor airflow rate over the 4-hour period shall be not less than that prescribed by Equation 29.3-9.

29.3.3.3.2.2 Outdoor air for other spaces.
Corridors and other common areas within the conditioned space shall be provided with outdoor air at a rate of not less than 0.06 cfm per square foot of floor area.
29.3.3.2.3 Local exhaust.  
Local exhaust systems shall be provided in kitchens, bathrooms and toilet rooms and shall have the capacity to exhaust the minimum airflow rate determined in accordance with Table 29.3.3.2.3.

### TABLE 29.3.3.2.3  
**MINIMUM REQUIRED LOCAL EXHAUST RATES FOR GROUP R-2, R-3, AND R-4 OCCUPANCIES**

<table>
<thead>
<tr>
<th>AREA TO BE EXHAUSTED</th>
<th>EXHAUST RATE CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchens</td>
<td>100 cfm intermittent or 25 cfm continuous</td>
</tr>
<tr>
<td>Bathrooms and toilet rooms</td>
<td>50 cfm intermittent or 20 cfm continuous</td>
</tr>
</tbody>
</table>

For SI: 1 cubic foot per minute = 0.0004719 m³/s.

29.3.3.2.4 System controls.  
Where provided within a dwelling unit, controls for outdoor air ventilation systems shall include text or a symbol indicating the system’s function.

29.3.3.2.5 Ventilating equipment.  
Exhaust equipment serving single dwelling units shall be listed and labeled to provide the minimum required air flow in accordance with this Code.

29.3.4 Enclosed Parking Garages  
29.3.4.1 Enclosed parking garages.  
Mechanical ventilation systems for enclosed parking garages shall operate continuously or shall be automatically operated by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Such detectors shall be listed in accordance with UL 2075 and installed in accordance with their listing and the manufacturers’ instructions. Automatic operation shall cycle the ventilation system between the following two modes of operation:

1. Full-on at an airflow rate of not less than 0.75 cfm per square foot [0.0038 m³/(s • m²)] of the floor area served.
2. Standby at an airflow rate of not less than 0.05 cfm per square foot [0.00025 m³/(s • m²)] of the floor area served.

29.3.4.2 Occupied spaces accessory to public garages.  
Connecting offices, waiting rooms, ticket booths and similar uses that are accessory to a public garage shall be maintained at a positive pressure and shall be provided with ventilation in accordance with Clause 29.3.3.1.

29.3.5 Systems Control  
29.3.5.1 General.  
Mechanical ventilation systems shall be provided with manual or automatic controls that will operate such systems whenever the spaces are occupied. Air-conditioning systems that supply required ventilation air shall be provided with controls designed to automatically maintain the required outdoor air supply rate during occupancy.

29.3.6 Ventilation of Uninhabited Spaces  
29.3.6.1 General.  
Uninhabited spaces, such as crawl spaces and attics, shall be provided with natural ventilation openings as required by the Ghana Building Code or shall be provided with a mechanical exhaust and supply air system. The mechanical exhaust rate shall be not less than 0.02 cfm per square foot (0.00001 m³/s • m²) of horizontal area and shall be automatically controlled to operate when the relative humidity in the space served exceeds 60 percent.

29.3.7 Ambulatory Care Facilities and Group I-2 Occupancies  
29.3.7.1 General.  
Mechanical ventilation for ambulatory care facilities and Group I-2 occupancies shall be designed and installed in accordance with this Code.
29.4 ACoustics, Sound Insulation and Noise Control

29.4.1 Scope

This clause covers requirements and guidelines regarding planning against noise, acceptable noise levels and the requirements for sound insulation in buildings with different occupancies.

29.4.2 Planning and Design Against Outdoor Noise (Acoustics)

29.4.2.1 General

Planning against noise should be an integral part of town and country planning proposals, ranging from regional proposals to detailed zoning, and three-dimensional layouts and road design within built-up areas. Noise nuisance should be fully recognized in zoning regulations.

29.4.2.1.1 Noise is either generated by traffic (road and rail) or it arises from zones and buildings within built-up areas (industry, commerce, offices and public buildings). For planning, the noise survey should examine all the possible causes of noise and consider the various factors causing actual nuisance.

29.4.2.1.2 Noise by night, causing disturbance of sleep, is more of nuisance than noise by day. For this reason, housing colonies that adjoin areas with heavy traffic movement during the night are liable to cause serious complaints. Also, the factories that work by night are liable to cause serious complaints if housing estates adjoin them. While planning, care should be taken that housing colonies are adequately setback from busy airports, state and national highways, factories, main railway lines and marshalling yards.

29.4.2.1.3 There are two aspects of defence by planning. The first is to plan so as to keep the noise at a distance. Under this aspect comes the separation of housing from traffic noise by interposing buffer zones, and the protection of schools and hospitals by green belts, public gardens, etc. The second is the principle of shading or screening. This consists of deliberately interposing a less vulnerable building to screen a more vulnerable one or by providing a solid barrier, such as a wall, between the source and the location to be protected.

29.4.2.2 Traffic Noise Levels

29.4.2.2.1 For Air Traffic

For guidance, approximate noise levels due to various types of aircrafts, measured on ground, when the aircrafts fly overhead at a height of 450 m, are given in Table 1.

Table 1 Typical Noise Levels of Some Aircraft Types

<table>
<thead>
<tr>
<th>Type of Aircraft</th>
<th>Flyover Noise Levels at 450m with Take-off Thrust (EPN dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>i) Boeing 737</td>
<td>107</td>
</tr>
<tr>
<td>ii) Boeing 747 - 200</td>
<td>103</td>
</tr>
<tr>
<td>iii) Airbus A 300</td>
<td>101</td>
</tr>
<tr>
<td>iv) Concorde SST</td>
<td>114</td>
</tr>
</tbody>
</table>

29.4.2.2.2 For Rail Traffic

Noise levels of some typical railway traffic are given in Table 2.

Table 2 Typical Noise Levels of Railway Trains

<table>
<thead>
<tr>
<th>Type of Aircraft</th>
<th>Flyover Noise Levels at 450m with Take-off Thrust (EPN dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>i) Steam train, 60 km/h</td>
<td>85</td>
</tr>
<tr>
<td>ii) Diesel train, 60 km/h</td>
<td>83</td>
</tr>
<tr>
<td>iii) Electric train, 60 km/h</td>
<td>77</td>
</tr>
</tbody>
</table>
29.4.2.2.3 For Road Traffic

The level of noise generated by road traffic depends upon such factors as the number of vehicles passing per hour, the type of traffic, the preponderance of heavy vehicles, average speed, gradient and smoothness of traffic flow. The smoothness of traffic flow also affects variability of the noise and is governed by such things as roundabouts and traffic lights, and the volume of traffic and pedestrian movement with their effects on stopping, starting and overtaking. The level of traffic noise fluctuates continuously and the way it does has a considerable effect on the nuisance caused. For assessing traffic noise, noise is measured in dB(A). Because of the fluctuating nature of traffic, noise levels due to different volumes of traffic flow with a varying mix of vehicles are given in Table 3.

Table 3 Typical Noise Levels Due to Free-Flowing Road Traffic (Clause 29.4.2.2.3)

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of Traffic</th>
<th>L_{10} 30 m from Edge of Road, dB (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>5000 vehicles per 18 hour day (10 percent heavy vehicles), 50 kmph</td>
<td>65</td>
</tr>
<tr>
<td>ii)</td>
<td>10,000 vehicles per 18 hour day (20 percent heavy vehicles), 60 kmph</td>
<td>70</td>
</tr>
<tr>
<td>iii)</td>
<td>10,000 vehicles per 18 hour day (40 percent heavy vehicles), 80 kmph</td>
<td>75</td>
</tr>
<tr>
<td>iv)</td>
<td>20,000 vehicles per 18 hour day (40 percent heavy)</td>
<td>77</td>
</tr>
</tbody>
</table>

NOTE – The values are applicable to free flowing traffic without honking.

29.4.2.3 Outdoor Noise Regulations

The outdoor noise regulations in force from time-to-time shall be complied with this Code.

29.4.2.4 Planning and Design

29.4.2.4.1 For Air Traffic

a) Flyover noise – Flyover noise is that which occurs under flight paths close to airports and is the most serious and common problem. As the aircraft passes overhead the noise level at any particular location rises to a peak and then decreases.

b) Ground noise – The noise emitted by an aircraft during ground operations is less variable in direction than flyover noise, but is usually of a longer duration.

29.4.2.4.1.1 Aircraft noise may disturb sleep, rest and communication, and as such may be considered potentially harmful to health. It is important that no new development is carried out within areas where the expected noise levels will cause mental and physical fatigue or permanent loss of hearing. In case development in such areas is essential, adequate sound insulation shall be provided for the building.

29.4.2.4.1.2 As the problems caused by aircraft noise have become more acute, a number of methods have been devised for evaluating noise exposure in the vicinity of airports. They all combine many factors into a single number evaluation. A commonly used criterion is the noise exposure forecast (NEF). The NEF is used primarily to develop noise contours for areas around airports. It has been accepted generally that noise exposure forecast levels greater than NEF 40 are unacceptable to people while levels less than NEF 25 are normally acceptable.

29.4.2.4.1.3 While it is theoretically possible to provide sufficient insulation to achieve an acceptable indoor noise environment in the area of very high outdoor noise, there is a level above which aircraft noise seriously affects living conditions no matter how much sound insulation has been applied to the dwelling unit. For this reason it is
recommended that no residential development be allowed beyond the NEF 35 level.

29.4.2.4.1.4 During summer months, the windows are normally kept open for adequate ventilation. In view of this, no matter how much sound insulation is provided for the building structure, the noise level inside the room can never be less than 10 dB below the outdoor noise level. For very critical buildings, such as buildings necessary for maintaining and supplementing the airport services, and for commercial development, such as hotels, it is possible to provide sealed windows and to centrally air-condition the entire building. However, it is not feasible for most of the residential developments in the country. In such cases proper zoning regulations and siting of vulnerable buildings away from aircraft noise are of vital importance.

29.4.2.4.2 Rail Traffic

This is a very serious source of noise in built-up areas, both by day and by night. Railway cuttings reduce the spread of noise, whereas embankments extend it. The elevated railway on viaducts or embankment is very common in built-up areas. The elevation increases exposure to noise but in addition the construction of the viaduct may affect the propagation of noise. In this respect solid embankments are preferable to built-up arches, which tend to act as sound boxes. Worst of all are the steel bridges, which greatly magnify the noise due to vibration. Uphill gradients are another feature tending to increase noise, especially of heavy goods trains.

29.4.2.4.2.1 Wherever possible, no residential or public building zone should abut onto railway lines, especially in the marshalling yards which are particularly objectionable because of the shrill, clanging and intermittent noise they generate, often at night. The appropriate zones alongside railway lines are industrial and commercial buildings other than office buildings. Where these precautions are not practicable and housing has to abut on to railway lines, every attempt may be made to house as few people as possible in the vicinity of the railway lines.

29.4.2.4.2.2 Underground transportation system can be a major cause of disturbance for the neighbouring community. Very high noise levels are propagated to long distances by the underground high speed railway, as a result of wheel rail interaction. Both air-borne noise and ground or structure-borne vibration are potential sources of complaints. Noise control measures, therefore, need to be considered for the following:

   a) In station, where high noise levels are produced at the arrival and departure of trains;

   b) In tunnels, during high speed train movement;

   c) where an underground rail transit system passes close to existing structures or high rise buildings adequate attention should also be paid to the problem of ground vibration transmitted to the building, and proper isolation should be provided for critical areas;

   d) Wherever elevated railway tracks are provided, adequate measures should be taken to avoid the spread of noise in the surrounding built up areas; and

   e) In transit cars, where sound insulation is of vital importance to provide comfortable conditions for the comments.

29.4.2.4.3 Road Traffic

29.4.2.4.3.1 Convoys of long distance heavy trucks at night moving past through built-up areas cause serious noise complaints. On busy roads, the noise of continuous traffic may be a worse nuisance than that of railways. At least the same precautions may, therefore, be taken in the planning of dwellings in relation to arterial and trunk roads as with railways. Care may be taken that local housing roads do not provide short cuts for heavy traffic through residential areas. Hilly roads present the additional noise of gear changing. Trees with heavy foliage planted on both sides of carriageway help slightly to muffle the noise, provided the foliage extends for a considerable distance (30m or above).

29.4.2.4.3.2 Road traffic may give rise to serious nuisance particularly on busy thoroughfares, between continuous high buildings in main streets, at the traffic lights, near bus stops, on steep slopes and in parking spaces and enclosed yards.

29.4.2.4.3.3 For zoning and planning new buildings in urban areas it is recommended
that external $L_{A10}$ is limited to a maximum of 70 dB (A) when the dwellings are proposed to have sealed windows and 60 dB (A) when the dwellings are proposed to have open windows. Indeed it is desirable to confine major new residential development to locations subject to $L_{A10}$ levels substantially lower than those given above.

It is recognized, however, that within the large urban areas, the use of sites where the external $L_{A10}$ is greater than 60-70 dB(a) cannot always be avoided. In that case it is suggested to utilize such design solutions as barrier blocks in order to reduce external $L_{A10}$ noise levels to at least 60-70 dB(A) at any point 1.0m from any inward looking façade. When the orientation of site and the density of development are such that this cannot be fully achieved some form of dwelling insulation will have to be provided. It should be appreciated that where open windows are a must, the occupants would have to put up with discomfort if the above conditions are not met.

29.4.2.4 Certain other methods can often be utilized to provide economical and effective protection from noise:

a) Methods may be adopted to improve the smoothness of flow and reduce number of stopping and starting. This leads to an improvement even if it leads to increased flows. Flow linking of traffic lights, for example, may reduce noise nuisance.

b) Use of roads passing through residential areas may be prohibited to heavy commercial vehicles. An alternative would be to limit use by commercial vehicles to certain times of the day.

c) Use of honking may be prohibited near sensitive buildings, such as hospitals and the like.

d) Barriers may be provided to shield sites from noise.

29.4.2.5 Zoning

The zoning of the different cities shall be done by the town planning authorities, taking into account besides other aspects, the noise levels from different occupancies. Wherever necessary, experts in the field may be consulted.

29.4.2.6 Green Belts and Landscaping

Where relief from noise is to be provide by means of green belts these may be of considerable width and be landscaped. (In case of railway tracks, a minimum distance of 50 m to 70 m may be provided between the buildings and the tracks). The extent of relief that may be derived from the above may be estimated only after considering other environmental factors. Only thick belts of planting (greater than 30m) are of real value. Strong leafy trees may be planted to act as noise baffles. Shrubs or creepers may also be planted for additional protection between tree trunks; artificial mounds and banks should be formed where practicable. As little hard paving and as much grass as possible may be used. The creation of green belt is particularly advisable on the perimeter of aerodromes, along railway lines and arterial roads, through or past built-up areas and adjoining noisy industrial zones.

29.4.2.7 Highway Noise Barriers

Barriers are often the most effective means of reducing traffic noise around residential areas. They have the great advantage that they generally protect most or all of the sites. In nearly all situations, a well-designed barrier of even a modest height (say 3m) can at least ensure that all areas of open space are free from excessive noise levels.

There are two types of barriers that can be built to protect sites; one which are built solely for the purpose of reducing noise and two, which form part of the building complex (barrier blocks). Free standing walls and artificial mounds are typical examples of the first type while single and multi-storeyed dwellings and/or garages are the most common form of the second.

Of the two types, barrier blocks are more widely used because they are cheaper and also tend to form a more effective barrier overall because of their greater height and width. Barrier walls or mounds are more limited in their effect than barrier blocks for they protect little more than the area of the site close to ground level essentially because of the lack of height, as continuous walls much higher than 3m are often difficult to construct.
29.4.2.8 Special Problems Requiring Expert Advice
The purpose of noise control is to ensure that people are neither harmed nor disturbed by noise. In addition to provisions given in this Clause, special advice may be required for more complex situations, such as those listed in Annex E.

29.4.3 PLANNING AND DESIGN AGAINST INDOOR NOISE
29.4.3.1 Acceptable indoor noise levels in buildings
The generally acceptable noise levels inside buildings are given in Table 4.

Table 4 Acceptable indoor noise levels for various buildings (Clause 29.4.3.1)

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Noise Level dB (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Auditoria and concert halls</td>
<td>20-25</td>
</tr>
<tr>
<td>ii)</td>
<td>Radio and TV studios</td>
<td>20-25</td>
</tr>
<tr>
<td>iii)</td>
<td>Cinemas</td>
<td>25-30</td>
</tr>
<tr>
<td>iv)</td>
<td>Music rooms</td>
<td>25-30</td>
</tr>
<tr>
<td>v)</td>
<td>Hospitals and cinema theatres</td>
<td>35-40</td>
</tr>
<tr>
<td>vi)</td>
<td>Apartments, hotels and homes</td>
<td>35-40</td>
</tr>
<tr>
<td>vii)</td>
<td>Conference rooms, small offices and libraries</td>
<td>35-40</td>
</tr>
<tr>
<td>viii)</td>
<td>Court rooms and class rooms</td>
<td>40-45</td>
</tr>
<tr>
<td>ix)</td>
<td>Large public offices, banks and stores</td>
<td>45-50</td>
</tr>
<tr>
<td>x)</td>
<td>Restaurants</td>
<td>50-55</td>
</tr>
</tbody>
</table>

29.4.3.2 Vulnerable Buildings
Some buildings or parts of buildings are especially vulnerable to noise, for example, recording and radio studios, hospitals and research laboratories. These should not be sited near loud noise sources. Most vulnerable buildings contain some areas which are themselves noisy and in such buildings the less vulnerable elements should be planned to act as noise buffers. Most noisy buildings also contain quite accommodation, which equally may be planned to act as a buffer between the noisy part of the building and adjoining vulnerable buildings.

29.4.3.3 The details of site and internal planning and insulation requirements are covered under individual occupancies (5 to 12) as applicable to the respective character and sources of noise in different buildings.

29.4.3.4 Sound Insulation of Non-Industrial Buildings by Construction Measures
The desired (acceptable) noise levels and the recommend insulation values for the various areas may be achieved by providing sound insulation treatments by constructional measures. The details of the same are given in Annex F. The recommendations given in Annex F are applicable to non-industrial buildings like residences, educational buildings, hospitals and office buildings.

29.4.3.5 Special problems requiring expert advice (see 29.4.2.8 and Appendix E)

29.4.4 RESIDENTIAL BUILDINGS
29.4.4.1 Sources of noise nuisance
29.4.4.1.1 Outdoor noise
The main sources of outdoor noise in residential areas are traffic (aeroplanes, railways, roadways,) children playing, hawkers, services deliveries, road repairs blaring loud-speakers and various types of moving machinery in the neighbourhood and building operations.

29.4.4.1.2 Indoor noise
29.4.4.1.2.1 As far as indoor noises are concerned, conversation of the occupants, footsteps, banging of doors, shifting of the furniture, operation of the cistern and water closet, playing of radio, television, music system, cooling and ventilation machinery, etc. contribute most of the noise emanating from an adjacent room or an adjacent building. Noise conditions vary from time-to-time and noise which may not be objectionable during the day may assume annoying proportions in the silence of the night when quiet conditions are essential.

29.4.4.1.2.2 In the case of flats the main sources of noise are from other flats and from stairs, lifts and access balconies. Plumbing noise is another cause. In semi-detached
buildings, outdoor noises from streets are noticed more than indoor noises from neighbours.

29.4.4.2 Recommendations

29.4.4.2.1 Site Planning

The most desirable method is to locate the residential buildings in a quiet area away from the noisy sources like the industrial areas, rail tracks, aerodromes, roads carrying heavy traffic, etc.

29.4.4.2.1.1 To minimize ground reflection, the dwellings should be surrounded by the maximum amount of planting and grassed areas and the minimum amount of hard surfacing. This applies particularly to high density areas. Where for maintenance reasons a large amount of hard paving is necessary, it should be broken up by areas of planting and grassing. Narrow hard paved courts should be avoided between adjacent tall buildings.

29.4.4.2.1.2 Roads within a residential area should be kept to a minimum both in width and length, and should be designed to discourage speeding. Area-wise planning, with zones from which vehicular traffic is altogether excluded will greatly help to reduce noise. Roads with through traffic should be excluded from residential areas, but where sites have to be developed adjacent to existing major roads the same principles should be observed in the siting of blocks as with railway lines as covered under 29.4.4.2.1.

29.4.4.2.1.3 Play areas for older children should be sited as far away from dwellings as possible. Special care should be taken with old peoples’ dwellings. They should not be placed immediately adjacent to service entries, play spaces, or to any entrances where children may tend to congregate.

29.4.4.2.2 Internal Planning

The orientation of building in a locality should be planned in such a way as to reduce the noise disturbance from neighbourhood areas. The non-critical areas, such as corridors, kitchens, bathrooms, elevators and service spaces may be located on the noisy side and the critical areas, such as bedrooms and living space, on the quite side.

29.4.4.2.2.1 Window and doors

Windows and doors should be kept away from the noisy side of the building as given below, whenever possible:

a) when windows of a building, particularly those of bedrooms in apartments or flats, face roads carrying heavy traffic or other noises where the external noise is of the order of 80 to 90 dB(A), the building should be located at a distance of about 30m from the road, but a distance of 45m or more, where possible, should be aimed at for greater relief from noise.

b) When the windows are at right angles to the direction of the above type of noise, the distance from the road should be arranged to be about 15 to 25m; and

c) In case another building, boundary wall or trees and plantations intervene between the road traffic and the house/flat further noise reduction is achieved and in such cases the above distances may be reduced suitably.

29.4.4.2.2.2 Layout plans

It is desirable that rooms adjoining party walls and above/below party floors should be of similar use. By this means, bedrooms are not exposed to noise from adjoining living rooms, and there is less risk of disturbance of sleep.

In semi-detached houses, the staircase, hall and kitchen should adjoin each other on each side of the party wall, thus providing a sound baffle between rooms requiring quiet conditions.

Bedrooms should not be planned alongside access balconies, and preferably not underneath them. Where the approach is by an internal corridor, a sound baffle may usefully be provide by arranging internal passages and bathrooms between the corridor and the living room or bedrooms.
Water-closets should not be planned over living rooms and bedrooms, whether within the same dwelling or over other dwellings. Soil pipes should not be carried in ducts which adjoin living rooms or bedrooms unless the size of the duct next to these rooms is a solid wall containing no inspection openings. Refuse chutes should not be planned next to living rooms or bedrooms.

### 29.4.4.2.3 Sound Insulation

#### 29.4.4.2.3.1 Reduction of air-borne noise

The weighted sound reduction index, $R_w$, of partitions between individual rooms or apartments of a building unit shall be as given in Table 5. These values may, however, be suitably increased, where required, for critical areas.

**Table 5 Sound insulation between individual rooms (Air-Borne)**

(Clause 29.4.4.2.3.1)

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>$R_w$, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Between the living room in one house or flat and the living room and bedrooms in another</td>
<td>50</td>
</tr>
<tr>
<td>(ii)</td>
<td>Elsewhere between houses or flats</td>
<td>45</td>
</tr>
<tr>
<td>(iii)</td>
<td>Between one room and another in the same house or flat</td>
<td>35</td>
</tr>
</tbody>
</table>

**Notes**

1. Where communicating doors are provided, all doors should be so designed as to provide recommended insulation between the rooms.

2. There are cases when a set of houses or flats have to be built for the people who work at night and sleep during the day. It is desirable to consider the design of at least one such room in each of the houses or flats which will provide an insulation of about 45 dB in that room.

3. The insulation values referred to are applicable with doors and windows shut.

#### 29.4.4.2.3.2 Suppression of noise at the source itself

All items of equipment that are potentially noisy should be selected with care. Water-closet cisterns should not be fixed on partitions next to bedrooms or living rooms. Plumbing pipes should be isolated from the structures. Lift motors should be mounted on resilient supports. Access doors from machine rooms to internal staircases should be well fitted and of solid construction. Special noise control measures may be required for electrical and mechanical services such as diesel generators, outdoor air-conditioning units, cooling towers, etc.

#### 29.4.4.2.3.3 Reduction of air-borne noise transmitted through the structure

Reduction of air-borne noise requires the use of rigid and massive walls without any openings. Openings are the major cause of penetration of noise through a barrier. While designing it should be borne in mind that all components should provide a sound transmission compatible with that of the rest of the barrier so that an equivalent amount of sound energy is transmitted through each portion of the barrier.

Ventilating ducts or air transfer openings where provided should be designed to minimize transmission of noise. For this purpose, some sound attenuating devices may be installed in these openings.

All partitions should be sealed effectively where they butt against the rest of the structure. All doors and windows should be properly gasketed where a high degree of sound insulation is desired.
29.4.4.2.3.4 Reduction of structure-borne noise
This requires the use of discontinuous or non-homogeneous materials in the construction of the structure.

29.4.4.2.3.5 Reduction of impact noise
The floor of a room immediately above the bedroom or living room shall provide impact sound pressure level ($L_{nTw}$) not greater than 60 dB. For example, 150 mm thick concrete floor with (12mm) thick carpet covering would satisfy this requirement.

29.4.4.2.3.6 Main staircases in blocks of flats are often highly reverberant. Some of the surfaces at least (for example, the soffits of stairs and landings) should be finished with sound absorbent materials wherever required.

29.4.5 EDUCATIONAL BUILDINGS

29.4.5.1 Sources of noise nuisance

29.4.5.1.1 Outdoor Noise
The outdoor sources of noise produced on school premises, which cause disturbances within the school, include the noise arising from playground, playing fields and open-air swimming pools. Though playgrounds are used mainly during break periods, they are also used for games, physical education and at times when teaching is in progress in the adjoining class rooms.

29.4.5.1.2 Indoor noise
Indoor sources of noise are as follows:

a) Singing, instrumental and reproduced music which may take place in class rooms and in dinning and assembly halls particularly in primary schools. In secondary schools, specialized music rooms are generally provided:

b) The movement of chairs, desks and tables at the end of one period may disturb a class engaged in a lesson in a room below;

c) The shutting and openings of doors and windows which may occur at any time during teaching periods;

d) Audio-visual presentations in class rooms;

e) Wood and metal workshops, machine shops (engineering laboratories), typing rooms, etc. which produce continuous or intermittent sound of considerable loudness;

f) Practical work carried out in general teaching areas;

g) Gymnasia and swimming pools;

h) School kitchens and dining spaces where food preparation and the handling of crockery and utensils persist for the greater part of the school day; corridors and other circulation spaces; and

i) Plumbing and mechanical services.

29.4.5.2 Recommendations

29.4.5.2.1 Site planning
Where outdoor noise nuisance exists from local industry, busy roads, railway, airfields, sport grounds or other sources beyond the control of the school authority, school buildings should be sited as far as possible from the sources of noise.

29.4.5.2.1.1 Rooms should be planned in a manner so that the minimum amount of glazing is placed on the side facing the external noise.

29.4.5.2.2 Internal planning
The following principles should be observed in the detailed planning of educational buildings:

a) Grouping – Noisy rooms should be separated from quite ones, if possible. In general, it is desirable that rooms should be grouped
together in accordance with the classification given in 29.4.5.2.4.1.

b) Windows and ventilators – Windows of noisy and quiet rooms should not open to the same courtyard or be near to one another. Roof lights and ventilators over noisy rooms should be avoided, if they are likely to be a source of nuisance to adjacent upper floors.

c) Doors – Swing doors into rooms should only be used where no problem of sound transmission exists. Reduction of insulation between rooms and corridors due to doors must be borne in mind. The type and method of fitting of doors is important and necessary care shall be paid in this respect.

d) Sliding partitions should only be used where essential.

e) Opening planning and circulation areas – Where open planning is used to permit spaces, such as assembly halls, dining rooms or entrance halls to be used in association with each other or for circulation, the degree of disturbance caused by interfering noise to teaching areas needs careful consideration; traffic through such areas should be strictly controlled; full use should be made of sound absorbent treatments to reduce the spread of noise from one space to another (see 29.4.5.2.3).

29.4.5.2.3 Noise reduction within rooms

Sound absorbent materials play a useful part in reducing the built-up or air-borne noise at source. In rooms, such as, classrooms, assembly halls and music rooms, a fairly short reverberation time under occupied conditions is one of the requirements of the acoustic design. The maximum reverberation times permissible for this purpose are usually short enough to give adequate noise control but in addition, the reverberation time should not be excessive under empty conditions, because noise may occur in these rooms with very few occupants. Table 6 gives the reverberation times often arranged in occupied rooms for acoustic reasons and the maximum times recommended in the empty rooms for noise reduction; the times given are for a frequency of 500 Hz, but they should not be greatly exceeded at any frequency. When rooms are used for a variety of purposes, the reverberation period appropriate to the major use should be adopted.

29.4.5.2.3.1 Special attention should be given to noise reduction in schools for the deaf and schools for the blind. Deaf children are taught by means of hearing aids which cannot be used satisfactorily in high noise levels or in reverberant conditions. Blind children depend on good hearing for understanding speech and for detecting changes in environment. In both these types of schools, noise levels should be kept low and reverberation times short. As an example, the reverberation times in empty class-rooms should not exceed one second in schools for the blind or 0.5 second in schools for the deaf.

If rooms have large glazed panels or ventilation openings facing directly on the circulation areas, human traffic passing by the rooms should be controlled. Preferably baffled ventilation system or double windows should be used. (Fan-lights over doors should be fixed and glazed).

f) Furniture – In all educational buildings, regardless of the character of the floor finish, rubber buffers should be fitted to the legs of chairs and tables.

<table>
<thead>
<tr>
<th>Room</th>
<th>Reverberation Time, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual for Acoustic</td>
<td>Maximum† for Noise</td>
</tr>
<tr>
<td>Reasons (Full)</td>
<td>Control (Empty)</td>
</tr>
<tr>
<td>1047</td>
<td></td>
</tr>
</tbody>
</table>
i) Assembly halls 1.0 – 1.25 according to size 1.5 – 2.5 according to volume of hall
ii) Music teaching rooms 0.75 – 1.25
iii) Gymnasia and indoor swimming pools - 1.5
iv) Dining rooms - 1.25
Classrooms 0.75 1.25
v) Headmasters room and staff rooms 0.5 – 1.00 1.0

1) Shorter reverberation times are desirable for noise control whenever possible

29.4.5.2.4 Sound Insulation

29.4.5.2.4.1 Air-borne Noise

For purposes of sound insulation, rooms in educational buildings may be classified as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Noise Producing</th>
<th>Workshops</th>
<th>Kitchens</th>
<th>Dining rooms</th>
<th>Gymnasiums</th>
<th>Indoor swimming pools</th>
<th>Assembly halls</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workshop</td>
<td>Kitchen</td>
<td>Dining rooms</td>
<td>Gymnasiums</td>
<td>Indoor swimming pools</td>
<td>Assembly halls</td>
</tr>
<tr>
<td></td>
<td></td>
<td>halls</td>
<td>rooms</td>
<td>rooms</td>
<td>halls</td>
<td>pools</td>
<td>halls</td>
</tr>
<tr>
<td>Class B</td>
<td>Producing but needing quiet at times</td>
<td>Lecture halls</td>
<td>Music rooms</td>
<td>Typing rooms</td>
<td>General classrooms</td>
<td>Practical rooms</td>
<td></td>
</tr>
<tr>
<td>Class C</td>
<td>Average</td>
<td>Laboratories</td>
<td>Offices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class D</td>
<td>Rooms needing quiet</td>
<td>Libraries</td>
<td>Studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class E</td>
<td>Rooms needing</td>
<td>Medical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

29.4.5.2.4.2 The recommended minimum sound reduction ($D_w$) between rooms of the same class is as follows:

| Class A | - | 25 dB |
| Class C or D | - | 35 dB |
| Class B or E | - | 45 dB |

29.4.5.2.4.3 Where a room is likely to have a dual use, for example, a dining room to be used as a classroom, the higher sound insulation value should be used.

29.4.5.2.4.4 The recommended minimum sound reduction ($D_w$) between rooms in different classes is 45 dB subject to the following:

a) In schools or institutes with a technical bias where noisy activities, such as sheet metal work, plumbing and woodwork, are likely to be practiced extensively in normal hours, category requiring more than 45 B isolation ($D_w$) form rooms of any other class.

b) Assembly halls and music rooms are special cases in that, as well as producing noise, they also require protection from it and may need more than 45 dB isolation ($D_w$) from rooms in Class A, if the latter are very noisy.

c) Circulation spaces may vary from a long and frequented corridor to a small private lobby and it is therefore difficult to give precise recommendations to cover them. For partitions between rooms in Class C and most corridors, a $R_w$ of 35 dB for the partition itself is adequate. For partitions between rooms in other classes and corridors, more or less insulation may be necessary, depending upon the specific usage.
The problem of noise in circulation areas is as a rule greatly mitigated in schools by the fact that classes usually change rooms together at regular times. In colleges and evening institutes, however, this is much less true and in such buildings particular attention should be paid to insulation between rooms and corridors.

29.4.5.2.4.5 Open plan schools

A new concept in school planning is the use of a large teaching area with simultaneous instructions imparted to several groups of students. These open plan teaching areas offer a different set of problems. Because of the limitations in achieving a great deal of attenuation across the space and related difficulties in noise control and speech interference, lecturing to a large number of students is not possible without interfering with neighbouring groups. The shape of such spaces may be as possible with a width to height ratio of 5:1 or greater.

In addition, special measures are required to be introduced to reduce the level of intruding speech to an acceptable value so that the various teaching groups are not disturbed and adequate privacy is maintained. Judicious positioning of partial height barriers 1.8 m to 2.1 m in height can improve the sound attenuation between teaching groups and the use of reflective screens can reinforce the speech locally without reflecting it to unwanted areas.

29.4.5.2.4.6 Impact noise

In the case of schools, the concrete floor of the room immediately above the teaching rooms shall provide an impact sound pressure level, $L'_{Tn,Te}$, not greater than 70 dB. For example, a covering of 6mm linoleum or cork tiles on concrete floor (hollow or solid) weighing not less than 220 kg/m² will usually meet the above requirement.

29.4.6 HOSPITAL BUILDINGS

29.4.6.1 General

Problems of noise control vary from hospital to hospital but the principles outline below apply to all types. A quiet environment in hospitals is desirable for patients who are acutely ill. Staff requires quiet conditions for consultations and examinations and also in their living and sleeping quarters. There have been rapid rises in noise levels in hospitals due to the higher levels of outdoor noise, increasing use of mechanical and mobile equipment (some of which is now brought much nearer to the patient in order to facilitate nursing procedure) and the introduction of loudspeaker, radio, television and call systems. Noise control in the hospital is made much more difficult by the extensive use of hard washable surfaces which reflect and intensify the noise. In most hospitals, windows to the open air and fanlights to corridors are usually open for the purpose of ventilation, admitting noise from outside and allowing it to spread through the building.

29.4.6.2 Sources of Noise Nuisance

29.4.6.2.1 Outdoor Noise

This may be classified into two main categories:

a) Noise from sources outside the hospital premises, for example, traffic and industrial noises; and

b) Noise from sources outside the building but usually within the control of the hospital authority, for example, ambulances, motor-cars and service vehicles, fuel and stores deliveries, laundries, refuse collection, trucks and trolleys.

29.4.6.2.2 Indoor Noise

A hospital is a complex building with many services and the numerous internal sources of structure-borne and air-borne noises are grouped into three main categories:

a) Noise consequent upon hospital routines. This category includes sources which transmit noise through both structure – borne and air-borne paths, many of which may be quite near to patients particularly those in wards, such as the following:
1) Wheeled trolleys of various kind, for food and medical supplies;  
2) Sterilizing equipment;  
3) Sluice room equipment including bedpan washers;  
4) Ward kitchen equipment;  
5) Footsteps;  
6) Doors banging;  
7) The handling of metal or glass equipment;  
8) Noises caused during maintenance and overhaul of engineering services; and  
9) Vacuum cleaners, mechanical polishers, etc.

b) Loudspeaker, radio or television, audible call system, telephone bells and buzzers, and other air-borne noises, such as loud conversation; and

c) Noises from fixed or mobile equipment and services not directly concerned with hospital routines. These include all the fixed services as given below:

1) plumbing and sanitary fittings;  
2) steam hot and cold water and central heating pipes;  
3) ventilation shafts and ducts;  
4) fans  
5) boilers;  
6) pumps;  
7) air compressors;  
8) pneumatic tubes;  
9) electrical and mechanical motors and equipment;  
10) lifts;  
11) laundry equipment; and  
12) main kitchen equipment (refrigerators, mixers, steam boilers, etc).

29.4.6.3 Recommendations

29.4.6.3.1 Site planning

Hospital sites with their high degree of sensitivity to outside noise should be as far away from outside sources as may be compatible with other considerations, such as accessibility and availability of services. The building should be so arranged on the site that sensitive areas like wards, consulting and treatment rooms, operating theatres and staff bedrooms are placed away from outdoor sources of noise, if possible, with their windows overlooking areas of acoustic shadow.

29.4.6.3.2 Detailed Planning

There is a very large number of units and room classification in hospital design and in planning the units in relation to each other and to the common services (such as X-ray departments, operating theatre suits and main kitchens), noise reduction in the sensitive areas should be weighed carefully against other design factors. Special care in overall planning and internal planning against noise is required in the planning within the building of units which are themselves potential noise sources, for example, children’s wards and outpatients’ departments, parts of which require protection against noise.

29.4.6.3.2.1 Unloading bays, refuse disposal areas, boiler houses, workshops and laundries are examples of service units which should be as far from sensitive areas as possible.

29.4.6.3.2.2 The kitchen is a constant source of both air-borne and structure-borne noise and should preferably be in a separate building away from or screened from the sensitive areas. If this is not possible and the main kitchens must form part of a multi-storey building, noise control is easier if they are placed below and not above the wards and other sensitive rooms so as to facilitate the insulation of the equipment and machinery in order to reduce the transmission of structure-borne noise to a minimum.

29.4.6.3.2.3 In ward units, the kitchens, sluice rooms, utility rooms, sterilizing rooms and other ancillary rooms, need to be placed quite near to the beds if they are to fulfill their purposes, which are all sources of noise. Some form of noise baffling between open wards and rooms of this kind will be needed.

29.4.6.3.3 Reduction of Noise at Service

In view of the difficulty of suppressing noise in hospital buildings, it is important to eliminate noise at its source wherever possible.
29.4.6.3.3.1 Use of resilient material

Mats of rubber or other resilient material on draining boards and rubber-shod equipment will greatly reduce noise from utility rooms, sluice rooms and ward kitchens. The use of plastics or other resilient materials for sinks, draining boards, utensils and bowls would also reduce the noise. Many items of equipment especially mobile equipment, such as trolleys and beds, may be silenced by means of rubber-tyred wheels and rubber bumper and the provision of resilient floor finishes (see 29.4.6.3.4.1). The latter also reduces footstep noise. Silent type curtain rails, rings and runners should be used. Lift gates and doors should be fitted with buffers and silent closing gear. Fans and other machinery should be mounted on suitable resilient mountings to prevent the spread of noise through the structure.

29.4.6.3.3.2 Other measures

Noise from water or heating pipes may be reduced by installing systems which operate at comparatively low pressure and velocities. Silencing pipes and specially designed flushing action reduce water closet noise at source and make structural measures easier to apply. The ventilation system should be designed so as not to create a noise problem. Silent closers should be fitted to doors.

29.4.6.3.4 Reduction of noise by structural means

29.4.6.3.4.1 Insulation

Since the various departments or units may be planned in many ways, only general guidance on the insulation values for walls and partitions is given as below:

a) It is recommended that walls or partitions between rooms should normally have a $R_w$ of at least 40 dB. Higher values of $R_w$ of at least 45 dB are necessary where a noisy room is adjacent to one requiring quiet conditions. Doors should be solid with close fitting in the frames.

b) There is little insulation value in double swing doors and where these are fitted in a noisy room the opening should be planned so that it is screened from areas requiring quiet by a baffle lobby lined with absorbent material. Very high insulation values may be necessary in special cases and exceptional measures may be required.

c) Solid floors with floating finishes and resilient surfaces are necessary particularly between wards and other parts of the building. Ordinary timber board on joist floors should never be used.

d) Conduits, ventilation ducts, chases, etc. should be constructed so as not to form easy by-pass for disseminating noise about the building, and should be provided with sufficient sound insulation. Pipe ducts should be completely sealed around the pipes where they pass through walls or floors. Ducts carrying waste or water pipes should be lined with sound insulating material to prevent noise from the pipes passing through duct walls into the rooms through which they pass.

29.4.6.3.4.2 Absorption

Most surfaces in hospitals should be easily cleanable, so as to prevent the build-up of bacteria which may cause cross-infection. Many sound absorbent materials of a soft nature and difficult to clean are unsuitable for use in some hospital areas and lose much of their effectiveness, if painted for hygienic reasons.

Some porous materials with very thin non-porous coverings (like mineral wool covered with thin plastic sheets) have good sound absorption and when covered with a perforated sheet metal facing can be used in most areas requiring a washable acoustical treatment. In noisy areas, such as corridors and waiting rooms, however, a wider choice of absorbents is available.

In the ward, bed curtains, window curtain etc, add to the absorbent properties of the room.
and help reduce reverberation in otherwise hard surfaced surroundings.

29.4.6.3.5 Sensitive areas such as operation theatres, Doctors’ consultation rooms, intensive care units (ICU) require special consideration against noise control. Apart from outdoor noise, a common problem is the transmission of sound between the consulting room and the waiting room. To ensure silence, a sound isolation $D_w$ of 45 B (A), between the rooms shall be provided. If the doors are directly connected by a single communicating door it will not be possible to achieve these values of isolation $D_w$. To obtain 40-45 dB(A) insulation between communicating rooms, it is necessary to provide two doors separated by an air gap, such as lobby or corridor.

29.4.7 OFFICE BUILDINGS

29.4.7.1 General

Modern office buildings are often noisier than older buildings due to the use of thinner and more rigid forms of construction, harder finishes, more austere furnishings and use of business machines.

29.4.7.2 Source of noise nuisance

29.4.7.2.1 Indoor noise

Main sources of indoor noise include the following:

- a) Office machines, such as typewriters, and printers;
- b) Telephone conversation;
- c) Noise from the public admitted to the building;
- d) Footsteps, voices and slamming of doors in circulation spaces, lift doors and gates;
- e) Sound reproduction in staff training rooms, conference rooms and recreation rooms, etc;
- f) Handing of crockery and utensils in canteens and kitchens; and
- g) HVAC and lift machinery.

29.4.7.3 Recommendations

29.4.7.3.1 Site planning

Rooms demanding quiet conditions should be placed on the quiet side of the site. Even on quiet thoroughfares, these rooms should also not be planned at street level. They should also not be planned on enclose yards used for the parking of cars, scooters, etc. Where, however, the problems cannot be resolved by planning, the provision of double windows may be necessary.

29.4.7.3.2 Detailed planning

29.4.7.3.2.1 Noise reduction within rooms

The reverberation time should not exceed 1.0 s in all general offices of the types listed in 29.4.7.3.2.2 to 29.4.7.3.2.6. In small private offices, the reverberation time should not exceed 0.75 second, in very large offices the reverberation time may be increased to 1.25 s. For canteens, the recommended maximum reverberation time is 1.25 s.

29.4.7.3.2.2 Large general offices

The grouping of departments and machines together in one room should be avoided wherever possible. Where supervision is necessary, the provision of glazed screens carried up to the ceiling should be considered. If it is essential to the work for an office for machine operators and clerks to work side by side in the same room, the machines should be enclosed by panels or low screens lined with absorbent material and the ceiling should be sound absorbent. In addition, the machines should be as quiet as possible in operation and mounted on suitable resilient mountings.

Note – A quiet area should be planned for prolonged telephonic conversation.

29.4.7.3.2.3 Light weight construction

Modern construction methods and economy dictate the use of light weight construction for many office buildings. While the light weight materials lead to fast fabrication and erection and also effect considerable economy in the building structure, they may lead to tremendous sound insulation problems between adjacent offices and areas. Light weight construction is also frequently employed for the sub-division of large space into executive cabins and secretarial areas. Where such construction is considered desirable, efforts should be made to provide a
double-skin panel. The panels should be isolated from each other as far as possible either by the use of separate framing or by the use of elastic discontinuities in the construction, and a sound absorbing material may be introduced in the air cavity between the panel. The partitions should be full height up to the bottom of the roof above and any openings required for air movement should be provided with sound attenuators compatible with the rest of the partition.

When light weight floors are provided in multi-use buildings, adequate attention shall be paid to the question of air-borne and structure-borne noise transmission from the upper floors to the floors below. For effective reduction of air-borne noise, a double panel hollow floor construction may be employed with some heavy sound damping material introduced between the panels and the panel isolated from each other. The sound damping material could be sand, mineral wool, etc. In case impact noise isolation is also required, the upper panel should be effectively isolated from the rest of the floors and building structure. The choice of the isolation layer would of course depend upon the lowest frequency of interest.

Another point to be kept in mind when going in for light weight construction is to ensure that the light weight panels are not in resonance with the natural frequencies of any mechanical equipment installed inside the building. Light weight materials have high natural frequencies well within the audio range and may resonate or vibrate due to an applied vibratory force. This vibratory force is caused by mechanical equipment, road traffic, rail traffic, etc. Special measures also need be taken to isolate either the source or the building so as to reduce the amount of vibration transmitted to the building structure.

29.4.7.3.2.4 Open plan offices

A new concept in office planning is the use of open plan offices. Large open floor spaces are converted into an office area with senior executives, junior executives and secretarial staff all seated within the same area without the use of any partitions or walls. While this method of planning is appreciated, it leads to a problem of inadequate acoustical privacy between adjacent work spaces. Speech privacy in open plan offices is defined by the speech interference level of intruding noise. Speech privacy between two adjacent rooms or spaces is, therefore, a function of two key parameters: noise reduction of the intervening partition and background noise levels.

Special design measures are, therefore, required to reduce the level of intruding sounds at work places to acceptable low value so that people are not disturbed and adequate privacy is maintained. Some special measures which might be considered for such open plan offices are the use of an acoustical ceiling together with partial height barriers between work spaces, all designed to provide adequate privacy between adjacent work spaces. In addition use may have to be made of an electronic background masking noise system which provides a constant level of a generally acceptable background noise in the entire office area. The masking noise system is a very useful concept in open plan office design because by raising the background level at every workplace, intruding noises are made less disturbing. A background music system cannot serve as a noise masking system because the music does not have a constant spectrum or sound level. In fact the background noise masking system must be introduced gradually without the knowledge of employees. The air conditioning system can also be used to generate background masking noise if the noise level from the fans, ducts and grills is suitably tailored to generate the desired frequency spectrum. However, it is not simple to predict the noise level of air conditioning components accurately. On the other hand, the electronic system enables both the level and the spectrum of the background noise to be accurately adjusted to suit individual job requirements.

29.4.7.3.2.5 Office equipment rooms

It is important that machines like typewriters, printer, etc. should be quiet in themselves and also be fitted with resilient pads, to prevent the floors or tables on which they stand from acting as large radiating panels. It is desirable to locate machines further apart and to apply sound absorbent treatment to the ceiling.

29.4.7.3.2.6 Banking halls

If banking halls are large and lofty, noise nuisance tends to be aggravated. It is advisable to avoid high reflective ceilings. The worst effects may be reduced by segregating the noise from the quiet operations and screening one from the other and by applying sound absorbent materials to the surfaces of the ceilings, screens and nearby walls. Resilient flooring is also recommended.
29.4.7.3.2.7 Public offices and waiting spaces
Noise nuisance may be minimized by the provision of resilient flooring, sound absorbent ceilings and heavy full height screens between the public space and the clerical office.

29.4.7.3.2.8 Canteens
The provision of a sound absorbent ceiling, resilient flooring and the use of plastic trays and tables with ‘quiet’ tops are recommended.

29.4.7.3.2.9 Circulation spaces
The effective length of long corridors should be limited by providing swing doors at intervals. Hard floor finishes and board and batten floors in corridors should be avoided. The provision of a sound absorbent ceiling in corridors is recommended. Floor ducts should be planned on one side of corridors.

The noise from slamming of doors may be reduced by fitting automatic quiet action type door closers. Door buffers are useful but may reduce insulation of air-borne sound due to the inevitable gaps between buffers. Continuous soft, resilient strip let into the door frames is preferable. The use of quiet action door latches is recommended.

Staircases and lifts should be isolated from quiet rooms and should have silent type doors.

29.4.7.3.3 Requirement of sound insulation
With open window (single or double) the sound reduction ($D_w$) will be 5-10 dB, and with sealed double windows it will be 40-45 dB. Intermediate values are obtainable with closed openable windows (single or double) but only, of course, at such times as ventilation may be dispensed with. Having to choose between ventilation and noise exclusion is a serious handicap to efficient working in offices. In large office blocks on noisy sites, consideration should be given to the provision of sealed double windows and mechanical ventilation at least in the offices on the sides of the building exposed to noise.

29.4.7.3.3.1 The insulation necessary between adjoining rooms, both horizontally and vertically, depends upon the amount of noise created within the rooms, the amount of intruding noise and whether it is important that conversation should not be overhead between rooms. Generally a sound isolation value ($D_w$) of 30 dB between one room and another room in office is recommended.

29.4.7.3.3.2 The following list may be considered as broad classification of noise producing rooms and rooms requiring quiet though many offices fall into both categories. Where rooms in opposing categories are planned adjacent to each other, a sound reduction ($D_w$) of at least 45 dB should be provided between them.

<table>
<thead>
<tr>
<th>Noise Producing Rooms</th>
<th>Rooms Requiring Quiet Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance halls, staircases and corridors used by the public</td>
<td>Executive’s rooms, Conference rooms and Board rooms</td>
</tr>
<tr>
<td>Lifts and lift halls</td>
<td>Interview rooms</td>
</tr>
<tr>
<td>Motor and plant rooms</td>
<td>Offices for one or two persons</td>
</tr>
<tr>
<td>Lavatories</td>
<td>Medical officer’s rooms</td>
</tr>
<tr>
<td>Public offices</td>
<td>Sick rooms</td>
</tr>
<tr>
<td>Canteen and kitchens</td>
<td>Rest rooms</td>
</tr>
<tr>
<td>Office machine rooms</td>
<td>Libraries</td>
</tr>
<tr>
<td>Recreation rooms</td>
<td>Telephoning rooms</td>
</tr>
<tr>
<td>Large general offices</td>
<td>Cinemas and projection rooms</td>
</tr>
</tbody>
</table>

a) rooms requiring quiet (as listed 45 dB above) on a quiet site where privacy is required;
b) rooms requiring quiet (as listed 40 dB above) but on a noisy site or where a lower degree of privacy is tolerable;
c) clerical offices in which noise levels of 20-30 dB not constitute a major nuisance.

29.4.7.3.3.3 It is recommended that the minimum sound reduction index, $R_w$ for floors should be 45 dB, and the floors should have a resilient finish.
29.4.8 HOTELS AND HOSTELS

29.4.8.1 General
Hotels and hostels are primarily used as dwelling units, and hotels also provide for public entertainment. The most serious risk of course is disturbance to sleep, and adequate care, therefore, need be taken to protect the occupants from being disturbed by outdoor and indoor noise.

29.4.8.1.1 Outdoor noise
Hotels near railway stations, airports, highways and those situated in highly urbanized areas are especially vulnerable to outdoor noise. The outdoor noise in many of the areas is of a high level even late at night and in the early morning. The noise could also be due to other types of activities such as building construction activity (pile driving, concrete mixing, etc) and various types of portable utility equipment, such as compressors or generators.

29.4.8.1.2 Indoor noise
In so far as indoor noise is concerned, the noise could be due to the occupants themselves, which is transmitted from one room to the other. It could also be due to public functions and late night use of restaurants located in the hotel as also due to miscellaneous utility equipment installed for providing and maintaining the services in the hotel, such as, air conditioning equipment, pumping equipment, power laundry and kitchen. Sometimes hotels equipped with standby generators are a potential source of noise. Another source which could lead to disturbance to the occupants is the plumbing.

29.4.8.2 Recommendations

29.4.8.2.1 Site planning
While it is desirable to locate the hotel, or hostel away from an area where there is a high ambient noise level, many a time these have to be located in noisy areas for public convenience. Hotels near airports and railway stations are becoming popular because they are convenient for passengers in transit. Hotels located in the commercial areas of a city are also a commercially viable proposition and many a time this factor outweighs the other problems associated with such a location. When a reasonably quiet location is not possible, it is desirable that adequate measures be considered to provide a comfortable acoustical environment for the occupants.

29.4.8.2.2 Internal planning
Where a hotel is located in a noisy environment, the provision of sealed windows (single or double) and provision of an air conditioning system is desirable for rooms exposed to noise. The requirements for the windows would of course depend upon the level and character of noise in the area.

The general recommendations for satisfactory acoustical design of hotels are given in 29.4.8.2.2.1 to 29.4.8.2.2.7.

29.4.8.2.2.1 Hotels of all classes shall by necessity provide good protection against indoor noise. Since hotels can be considered as flats, the standards of protection recommended for flats are also applicable to hotels. Partition between guest rooms and between rooms, corridors and floors shall not be less than 115 mm brick wall plastered or equivalent. The floors shall have proper impact insulation. Special attention should be paid to built-in wall cupboards as these are potential areas of sound leakage. These will not serve as sound insulating partitions and may not be relied upon to increase the insulation value of partitions against which they may be built. In fact, partitions between adjoining rooms should be continuous behind the cupboards. Use of silent type door gear and cupboard catches is also highly desirable.

29.4.8.2.2.2 Door openings on opposite sides of corridors shall be staggered and doors be provided with gaskets on head, sides and threshold. Inter-communicating doors should be double doors, fully gasketed. Doors should also have quiet action latches. Whenever possible, rooms should be entered through a baffle lobby. Wherever possible, corridor walls should not have ventilators unless they are double-glazed and non-openable.

29.4.8.2.2.3 Corridors and staircases may have resilient floor coverings and sound absorbent ceilings are desirable unless the corridor is fully carpeted. Staircases and lift wells may be cut off from corridors by means of swing doors and, if possible, isolated from
guest rooms by linen stores or similar rooms. Room service pantries on floors can also be a source of noise and may be separated from corridors by baffle lobbies, unless the rooms themselves have baffle lobbies.

29.4.8.2.2.4 Except within the same suite, bathrooms should not be planned next to bedrooms. Where this is unavoidable, internal pipe shafts with heavy walls, un-pierced on bedrooms side may be used as means of separation. It is important to choose quiet type of sanitary fittings and to design the plumbing system so as not to create noise, that is by avoiding sharp bends, restrictions of flow, quick – action valves that might cause water hammer, etc.

29.4.8.2.2.5 Air conditioning system should be quiet in operation. Care should also be taken that the air conditioning ducts do not lead to a cross-talk problem between rooms. Suitable acoustical lining would need to be provided in the ducts consistent with the fire safety requirements of the buildings.

29.4.8.2.2.6 Large hotels often have banquet halls and conference halls which are separately hired out for public and private functions. Late night restaurants and night clubs are also popular and functions in all these areas may go on well into the night. It is therefore essential that these rooms be effectively isolated from bedrooms and effective insulation form all possible noise source is considered. Here it is not only necessary to consider the air-borne sound insulation but it is also necessary to consider the question of structure-borne and impact noise transmitted from areas where there might be dancing late into the night.

29.4.8.2.2.7 While most of the noise problems encountered in hotels are applicable to hostels, the latter are normally of more economical construction and, therefore, cannot cater for special sound insulation provisions. However, as far as possible, precautions should be taken to provide comfortable conditions in hostel rooms. This is especially true for student hostels where each room is also a living room. Students might play music or have loud discussions late into the night.

This may disturb sleep or study of other students. Proper precautions should, therefore, be taken to provide satisfactory conditions.

29.4.9 INDUSTRIAL BUILDINGS

29.4.9.1 General

Industrial buildings are primarily producers rather than receivers of noise. The level of industrial noise commonly exceeds that from any other source with the exception of aircraft. As compared with traffic noise, its effects are less widespread but it is often more annoying in character.

29.4.9.1.1 Many industrial noises contain very strong high frequency whines, screeches and clatter – these components are relatively more attenuated by passage through the air and by the insulation of light structure than are lower frequencies.

29.4.9.2 Sources of industrial noise

29.4.9.2.1 Noises in industrial buildings are mainly of indoor origin. Noise in factories and workshops is generally caused by machine tools and by operations involved in making and handling the product and they are classified into the following groups, depending upon how the noise energy is generated.

29.4.9.2.1.1 Impact

Noise caused by impact is the most intense and widespread of all industrial noises. It is normally coupled with resonant response of the structural members connected to the impacting surface. Common sources of this type of noise are forging, riveting, chipping, pressing, tumbling, cutting, weaving, etc. Intense impact noise may also be produced during handling of materials as in the case of sheared steel plates falling one over another in collecting trays in a steel factory. Impact noise is usually intermittent and impulsive in character, but it may also be continuous as in the case of tumbling.

29.4.9.2.1.2 Friction

Most of the noise due to friction is produced in such processes as sawing, grinding and sanding. Friction also occurs at the cutting edge on lathes and other machine tools and in brakes and from bearings. The spectrum of frictional noise often predominates in high frequency and is very unpleasant in character.

29.4.9.2.1.3 Rotation and reciprocation

A rotating or reciprocating machine generates noise due to unbalanced forces and/or pressure fluctuations in the fluids inside the machines. In many cases, the moving surfaces radiate noise directly and in other cases, the pressure fluctuations are
transmitted to the outer casing of the machine from where they are radiated as noise. Interaction of rotating component with the fluid stream can also give rise to pure tone components, such as the whine in a turbine. Since most machine casings have radiation efficiencies of unity in the higher frequency range, the amount of sound radiated is often substantial.

29.4.9.2.1.4 Air turbulence
Noise may be generated by rapid variation in air pressure caused by turbulence from high velocity air, steam or gases. Common examples are the exhaust noise from pneumatic tools and air jets. The noise is intense, and broad based in character and the frequency criteria depends on the size of the jet. The intensity increases rapidly with the velocity of the air stream.

29.4.9.2.1.5 Noises with pure tone components
Whining noise from turbines and humming noise from transformers come under this group.

29.4.9.3 Noise criteria
29.4.9.3.1 Hearing damage-risk criteria
Continuous exposure to high noise levels may result in permanent noise induced hearing loss in the course of time. Damage-risk criteria specify the maximum levels and duration of noise exposure that may be considered safe. Generally accepted damage-risk criteria for exposure to continuous, steady broad band noise are shown in Table 7. Whenever the sound levels at the workers position in a factory exceed the levels and the duration suggested, feasible engineering controls shall be utilized to reduce the sound to the limits shown. If such controls fail to reduce sound levels within the levels of Table 7, personal hearing protection equipment shall be provided and used to reduce sound levels within the level shown.

29.4.9.3.2 Interference with Communication
In factories where audible warning signals are used, or where an operator follows the operation of his machine by ear, the background noise should not be so loud as to mask the signal or desired sound (the information sound) to be heard. Noise may be the cause of accidents by hindering communication or by masking warning signals.

29.4.9.4 Methods of reducing noise
29.4.9.4.1 Noise control by location
Machines, processes and work areas which are approximately equally noisy should be located together as far as possible. Areas that are particularly noisy should be segregated from quiet areas by buffer zones that produce and may tolerate intermediate noise levels.

29.4.9.4.2 Noise reduction by layout
The office space in an industrial facility should be as far as possible located preferably in a separate building. This building should not have a wall common with the production area. Where a common wall is unavoidable, it should be heavy with few connecting doors and no permanent openings.

29.4.9.4.3 Noise reduction at source
29.4.9.4.3.1 Selection of machinery
Noise should be reduced as near the source as possible. While the operational processes in a factory maybe fixed and may have no quieter alternative, careful selection of the machine tools and equipment to be used may considerably help attaining lower noise levels in the machine shop.

29.4.9.4.3.2 Reducing noise from potential sources
Impact that is not essential to a process should be quietened. Noise from handling and dropping of materials on hard surface may be reduced by using soft resilient materials on containers, fixing rubber tyres on trucks, trolleys, etc. Machine noise may be kept to a minimum by proper maintenance. Proper lubrication will reduce noise by friction conveyors, rollers, etc.

Table 7 - Permissible Exposure Limits for Steady-State Noise
(Clause 29.4.9.3.1)

<table>
<thead>
<tr>
<th>Sound Level (Show Response)</th>
<th>Time Permitted, T h min</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>16-00</td>
</tr>
<tr>
<td>86</td>
<td>13-56</td>
</tr>
<tr>
<td>87</td>
<td>12-08</td>
</tr>
<tr>
<td>88</td>
<td>1034</td>
</tr>
<tr>
<td>89</td>
<td>9-11</td>
</tr>
</tbody>
</table>
90  8.00
91  6.58
92  6.04
93  5.17
94  4.36
95  4.00
96  3.29
97  3.02
98  2.50
99  2.15
100 2.00
101 1.44
102 1.31
103 1.19
104 1.09
105 1.00
106 0.52
107 0.46
108 0.40
109 0.34
110 0.30
111 0.26
112 0.23
113 0.20
114 0.17
115 0.15

Notes
1 Where the table does not reflect the actual exposure times and levels, the permissible exposure to continuous noise at a single level shall not exceed the time T (in hours) computed from the formula:

\[ T = \frac{16}{2(0.2(L-85))] \]

Where

L is the work place sound level measured in dB(A).

2 When the daily noise exposure is composed of two or more periods of different levels, their combined effect should be considered rather than the individual effect of each. The combined levels may not exceed a daily noise dose, D of unity

Where D is computed from the formula:

\[ D = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n} \]

Where, \( C_1, C_2, \ldots, C_n \) indicate the total duration of exposure (in hours) at a given steady-state noise level; and \( T_1, T_2, \ldots, T_n \) are the noise exposure limits (in hours) for the respective levels given in the table or computed by the equation in Note 1. Exposure to continuous noise shall not exceed 115 dB(A) regardless of any value computed by the formula for the daily noise dose, D or by the equation given in Note 2.

29.4.9.3.3 The noise from the radiating surfacing may be reduced by reducing the radiating area. For example, if the area is halved, the noise intensity will be reduced by 3 dB and at low frequencies the reduction will be much greater.

29.4.9.3.4 Supporting structures for vibrating machines and other equipment should be frames rather than cabinets or sheeted enclosures. If an enclosure is used, precaution should be taken to isolate it and line it on the inside with sound-absorbent material. The noise radiated by machinery guards can be minimized by making them of perforated sheet or of wire mesh.

29.4.9.3.5 Reducing transmission of mechanical vibration

A vibrating source does not usually contain a large radiating surface but the vibration is conducted along mechanically rigid paths to surfaces that can act as effective radiator. If the rigid connecting paths are interrupted by resilient materials, the transmission of vibration and consequently the noise radiated may be greatly reduced. The reduction depends on the ratio of the driving (forcing) frequency of the source to the natural frequency may be determined from static deflection under actual load as given in Fig. 1. Higher the ratio between the two frequencies, lesser is the transmissibility, which is defined as the ratio of the force transmitted through the resilient isolator to the exciting force applied to it. Transmissibility and the equivalent noise reduction for various frequency ratios are given in Fig.2. For satisfactory operation, a ratio of 3:1 or more between the driving and natural frequencies is recommended.
Materials for isolators and their position are given below:

a) Material for Isolators – Vibration isolators are usually made of resilient materials like steel in the form of springs, rubber cork and felt.

1) Because of the large range of deflections obtainable in coil springs, they may isolate vibrations over a large spectrum of low frequencies. Metal springs transmit high frequency (from about two hundred to several thousand c/s) very readily. Transmission of these frequencies can be reduced by eliminating direct contact between the spring and the supporting structure. Rubber or felt pads may be inserted between the ends of the spring and the surfaces to which it is fastened.

2) Rubber in the form of pads may be used to isolate very effectively engines, motors, etc. It may be used in compression or in shear. Some rubber mountings use rubber-in-shear as the primary elastic elements and rubber-in-compression as a secondary element which furnishes snubbing action if the mounting is subjected to an overload.

3) Felt or cork or both may be used as resilient mats or pads under machine bases. The load per unit area shall be chosen to produce enough deflection for the isolation required; and shall be such that at this deflection, it is not loaded beyond its elastic limit.

b) Position of Isolator – The normal position of the isolators is between the machine and its foundation. However, if the forcing frequency of the machine is low (less than 10 Hz) and vibration isolators with the requisite deflection for this location are not available, the machine may be bolted directly to an independent heavy inertia concrete base and the available
vibration isolators used below the concrete base.

1) Large press and drop hammers which create serious impact vibration in heavy machine shops may be mounted rigidly on very massive blocks of concrete having weights several times greater than the weights of the supported machines. The inertia blocks may, in turn, be isolated from the building structure by large wooden blocks and with thick pads of cork.

2) In critical installations (see Note), attempt should be made to locate the resilient mounts in a plane which contains the centre of gravity of the mounted assembly. It is also preferable to locate the mounts laterally as far away as possible from the centre of the machine.

Note: Critical installations are those installations where transmission of vibration from these installations will seriously hamper the normal working.

3) Rigid mechanical ties between vibrating machine and building structure, short-circuit or reduce the effectiveness of isolators. Loose and flexible connections should be inserted in all pipes and conduits leaving from the vibrating machine. Where flexible connections are impracticable, bends should be inserted into the pipes or the pipes themselves should be supported on vibration mounts for a considerable distance from the source.

4) Flexibility of foundation – The effect of flexibility of the foundation on the isolator transmissibility shall be considered in the selection of practical vibration isolating mountings. The simplified vibration isolation theory assumes a completely rigid foundation. However, in practice, this can never be achieved. The foundation is never actually completely rigid. Generally, the relatively low stiffness of the isolation system permits the assumption of the foundation to be rigid. However, if the stiffness of the isolator is allowed to become comparable to the foundation stiffness (or greater), the deflection of the isolator will become smaller and the foundation will also deflect with increased transmissibility and decreased isolator efficiency. In a dynamic sense, supporting foundation or floors should have natural frequency as high and be as stiff as possible compared to the system being isolated. Good design practice requires that the isolators should be designed assuming a rigid foundation with the stipulation that the selected machine isolation system frequency should be well below the foundation frequency. This point should specially be kept in mind when installing machines at upper levels in buildings because supported slabs generally have lower natural frequencies (low stiffness) than slabs on grade in basement or ground floor locations.

29.4.9.4 Noise reduction by enclosures and barriers (Noise Control)

29.4.9.4.1 Enclosures

Air borne noise generated by a machine may be reduced by placing the machine in an enclosure or behind a barrier. The enclosure may be in the form of close fitting acoustic box around the machine such that the operator performs his normal work outside the box and thus is not subjected to the high noise levels of the machine. The enclosure may be made of sheet metal lined inside with an acoustical material.

Where size of the machine, working area and the operation do not permit close-fitting enclosures, the machine may be housed in a room of its own. The inside of the enclosure should be lined with sound-absorbing materials to reduce the noise level of the contained sound. The bounding walls of the enclosures shall also have adequate transmission loss to provide desired insertion loss.

29.4.9.4.2 Barriers

A partial reduction of noise in certain directions may be obtained by ‘barriers’ or partial enclosures or partial height walls. Two-sided or three-sided barrier, with or without a top and
invariably covered on the machine side with acoustic absorption material should face a wall covered with sound-absorbing material. If the top of the enclosures is open, the reduction may be increased by placing sound-absorbing material on the ceiling overhead.

29.4.9.4.5 Acoustic absorption devices

29.4.9.4.5.1 Acoustic treatment of ceilings and side walls

In order to reduce the general reverberant noise level in machine shops, acoustical material be placed on the ceiling and side walls. With this treatment 3 to 6 dB reduction of middle and high frequency noise may be achieved. While the noise level at the source, affecting the operator, may not be reduced materially, the treatment would bring down the general noise level away from the source in reverberant field.

29.4.9.4.5.2 Functional around absorbers

For efficient noise reduction ‘functional sound absorbers’ may be clustered as near the machines as possible. These units may be suspended and distributed in any pattern to obtain lower noise levels within the machine shop. Compared on the basis of equal total exposed surface areas, functional sound absorbers have higher noise reduction coefficients (NRC) than conventional acoustical materials placed directly on ceilings and walls.

29.4.10 LABORATORIES AND TEST HOUSES

29.4.10.1 Sources of noise

29.4.10.1.1 Outdoor noise

In a test house or laboratory, where research workers and scientists are engaged in performing sophisticated experiments, the external noise is mostly contributed by noise emitting buildings (workshops, machine rooms), airports, railway stations and general traffic noises. The outdoor sources of noise in a college laboratory include noises produced in a playground as well.

29.4.10.1.2 Indoor noise

The following sources mainly contribute to indoor noises in research institutions/college laboratories.

a) workshops, machine rooms, cafeteria, etc.;

b) air-conditioning and exhaust fans;

c) noise-produced within the test house or laboratory while performing experiments; and

d) typing or other machine noises, telephone service, lift, sanitary services, etc.

29.4.10.2 Recommendations

29.4.10.2.1 Site planning

While planning for a laboratory or test house, care should be taken in the design that noise emitting installations should exist in its neighbourhood. However, where outdoor noises exist, such as from local factory, heavy traffic airports, railway lines, sport grounds or busy markets, buildings should be kept as far away as possible from the source of noise.

29.4.10.2.1.1 The window and door openings towards the noise sources should be minimal. Minimum amount of glazing should be placed on walls directly facing the noise sources.

29.4.10.2.2 Internal planning

29.4.10.2.2.1 Noisy places should be kept separate from the quiet ones. The location of laboratories or test houses should be so chosen that it is cut off from the noisy zones. Where there are offices attached to a laboratory, provision should be made to treat the offices and to use acoustical partitions, to achieve a sound isolation $D_w$ at least 35 dB.

29.4.10.2.2.2 In a laboratory, mostly hard reflecting surfaces and bare furnishings are found, which produce very reverberant conditions. The noise condition still deteriorates when noise producing instruments are switched on or a heavy object is dropped on the floor. Under these conditions, sound absorbing treatment of the space is very essential. Sound absorbing ceilings are recommended to deaden such noises. Rubber buffers may also be fitted to the legs of furniture.

29.4.10.2.2.3 In large span laboratories or test houses where scientists and researchers are engaged in work and/or simultaneously busy in calculations or desk work requiring high degree of mental concentration, use of sound absorbing screens is recommended.

29.4.10.2.2.4 Noise reduction between the test house or laboratory and corridors or general
circulation space should be well kept in mind and due care should be taken of the type of doors and the manner of their fitting etc. Transmission of noise through service ducts, pipes, lifts and staircases should also be guarded.

Telephones should preferably be placed in a separate small enclosure or acoustically efficient telephone booth.

29.4.10.2.2.5 To isolate a laboratory or a test house from structure borne noises originating from upper floor, sandwich type floor construction is recommended.

29.4.10.2.2.6 Wherever the provision of double glazed windows is necessary to reduce the heat losses, care should be taken to provide sealed double windows rather than double glazing in a single window.

Note – Double glazed windows for sound isolation should have a minimum gap of 100 mm between the two glasses.

29.4.11 MISCELLANEOUS BUILDINGS

29.4.11.1 Law courts and council chambers

It is important that law courts and council chambers be protected from the intrusion of outdoor noise and from indoor noise arising both from ancillary offices and circulation spaces. The general recommendations on site planning given in Part 3 apply to law courts and municipal buildings, but in the larger buildings at least, further protection against outdoor noise can be obtained by planning offices and other rooms around the court rooms or chambers, and separating the offices from the central rooms by means of corridors. This arrangement is usually convenient to the function of the buildings.

29.4.11.1.1 The wall between the corridors and the central rooms should have a sound reduction index, $R_N$, of not less than 50 dB (for example 230 mm brick) to insulate against airborne noise in the corridors. Entrances from halls or corridors into court rooms or counsel chambers should be through baffle lobbies with two sets of quiet action doors. Sound absorbing treatment on ceilings and upper parts or walls or entrance lobbies is recommended.

29.4.11.1.2 The whole of the floor of the court room or chamber including steps and seating areas set aside for the public should have a resilient floor finish to reduce the noise of footsteps and shuffling of feet. Any tip-up seats should be quiet in action. 

29.4.11.1.3 Sound absorbing treatment applied for acoustic purposes serves also to reduce the build-up of noise within the room and, part of the treatment should be applied in a band to the perimeter of the ceiling to absorb intruding outdoor noise. It is often desirable to keep the centre part of the ceiling free of absorbent material for acoustic reasons.

29.4.11.2 Libraries, museums and art galleries

Quiet conditions for reading and study are essential in these types of buildings and, since their occupancy is not noise producing, intruding noise is more noticeable and distracting. Every opportunity therefore should be taken to plan for noise defence, both in respect of siting of the building and internal planning. When possible, stack rooms, store rooms and administrative offices should be planned to screen reading rooms, print rooms and lecture rooms from noise sources. In public libraries, the reference library and lecture rooms should receive first consideration; the lending library, newspaper and periodical rooms have a higher background noise and are secondary in importance.

29.4.11.2.1 In large libraries, museums and art galleries echoes from lofty, large doomed or concave ceilings are often a nuisance. Small noises such as footsteps, coughs, chair scraping and closing of books are reinforced by reverberation, and concave surfaces even when treated with a sound absorbent may focus these noises. Treated flat ceilings, if not too high, obviate these troubles. Books on shelves in libraries constitute a valuable wall absorbent.

29.4.11.2.2 Floor finishes are important. The impact noise of footsteps on marble, terrazzo or wood block flooring, and especially on hardwood strip and batten flooring, can be disturbing both within the room in which the noise is generated and the rooms below. On solid floors, resilient floor finishes, such as rubber, cork and linoleum on an underlay, are highly desirable. In the children’s clauses of libraries and museums they are essential. In existing buildings, rubber linoleum or vinyl asbestos tiles laid over the floor in the traffic areas are often a solution to the problem.
29.4.11.2.3 Reference libraries in universities, research establishments, office buildings and science buildings having machines and testing benches, should be planned in a quiet part of the building. Walls enclosing the library should normally have a sound reduction index, $R_w$, of not less than 50 dB (for example 230mm brick) and baffle lobbies should be planned between the library and halls and corridors. Wall fencing on to corridors or other noisy areas should not have fanlights unless they are double-glazed and non-operable.

29.4.11.3 Auditoria and theatres

The sources of noise that have to be considered in concert halls, opera house, theatres and similar auditorium buildings are as follows:

a) Outdoor noise entering through walls, roofs, doors, windows or ventilation openings;

b) Noise from any other hall in the same building, especially if let out separately for revenue;

c) Noise from foyers, service rooms and other ancillary rooms, particularly rehearsal rooms; and

d) Noise from air conditioning plant, etc. and the cross-transmission of other internal noises via ventilating duct system.

29.4.11.3.1 Because of greatly increased outdoor noise, all auditorium buildings now need more care in siting than formerly. For listening to speech or music, very low background noise level is desirable; in concert halls especially the quietest possible conditions should be provided because the pauses and moments of silence which are an essential element of music cannot otherwise be given full value. Therefore, sites at crossroads or close to steel railway bridges, religious places or near churches where bell ringing is practiced, should be avoided unless very high standards of structural sound insulation are contemplated. Sites adjoining underground railways may also prove unsatisfactory at basement levels owing to low-pitched noise or rumble transmitted through the ground: special isolation measures need to be adopted for isolating large buildings from ground vibration of this sort.

29.4.11.3.2 Wherever possible, for concert halls and theatres on city sites a noise survey of the site should be made; a suitable sound reduction value for the structure of the building can then be chosen so as to keep down to certain maximum noise levels within the auditorium. The maximum octave-band sound pressure levels (SPL) recommended are given in Table 8.

<table>
<thead>
<tr>
<th>Type of Auditorium</th>
<th>Centre Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
</tr>
<tr>
<td>Concert Halls (dB(A)-25)</td>
<td>51</td>
</tr>
<tr>
<td>Drama Theatres and Cinemas (dB(A)-30)</td>
<td>55</td>
</tr>
</tbody>
</table>

29.4.11.3.3 The minimum standard of sound reduction index, $R_w$, likely to be required for the envelope of an auditorium in a city to protect it against external noise is of the order of 65 dB for a concert hall or 55-60 dB for a theatre. This reduction should be provided on all sides, but it would be reasonable to make the $R_w$ for the roof 5 to 10 dB less provided the building is not unduly exposed to noise from aircraft in flight. Surrounding the auditorium with ancillary rooms and foyers is an obvious and invaluable planning method of obtaining the required insulation against outdoor noise.
29.4.11.3.4 Ventilation intakes and returns are vulnerable features in the defence against external noise. They should be positioned so as to avoid exposure to noise, and in addition sufficient length of both inlet and outlet ducts should be provided with carefully designed silencers. The ventilation system should also be designed to avoid transmitting or adding to internal noise.

29.4.11.3.5 The most serious internal noise problem arises when there are two halls meant for separate use in the same building, especially if one of them is a concert hall. The latter is a very loud potential source of noise and requires a high standard of protection against strenuous noise. In these circumstances it is doubtful whether a ‘single’ wall can be adequate for insulating the two halls unless it is designed with a wide unabridged cavity. Separation by planning is preferable.

29.4.11.3.6 Other sources of internal noise are rehearsal rooms, scenery bays and workshops, stages of other halls where rehearsals or erection of stage sets might be in progress and foyers and bars where loud conversation might occur. The insulation of the internal walls should be adequate to protect the auditorium from these noise sources and the insulation should not be bypassed by openings, doorways, etc. The general noise due to banging of doors also needs to be taken care of; soft sealing materials should be provided for all doors to ensure quiet closing. For example, lipping with veneer plywood.

29.4.11.3.7 For detailed acoustical design of auditoria and conference halls reference may be made to good practice.

29.4.11.4 Cinemas
The main objective of the design should be to control noise from adjacent screens, the projection area, the foyer, and outside the cinema. The first of these, controlling noise from adjacent screens, is likely to be the most difficult with modern digital sound systems. As most cinemas are air conditioned, there will be some noise from services. To ensure reasonable listening conditions, this should be limited to 30 dBA. This will provide some masking of the noise from adjacent screens, but a high performance partition will still be essential. Masonry or lightweight construction may be used, and a typical performance specification for a lightweight wall separating two screens is given in Table 9. Cinema design, however, normally requires specialist acoustic advice.

Table 9—Typical sound insulation specification for wall separating two cinema screens
(Clause 29.4.11.4)

<table>
<thead>
<tr>
<th>Octave Band</th>
<th>Sound Reduction Index R, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>38</td>
</tr>
<tr>
<td>125</td>
<td>44</td>
</tr>
<tr>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>500</td>
<td>61</td>
</tr>
<tr>
<td>1000</td>
<td>57</td>
</tr>
<tr>
<td>2000</td>
<td>58</td>
</tr>
<tr>
<td>4000</td>
<td>57</td>
</tr>
<tr>
<td>8000</td>
<td>55</td>
</tr>
</tbody>
</table>

29.4.12 NOISE FROM BUILDING SERVICES
29.4.12.1 Mechanical. Electrical, air-conditioning, heating and mechanical ventilation, and other services are provided in almost all large buildings and some residential, commercial and industrial buildings. Noise control measures should be incorporated during the design and installation of such services to adhere to the recommended outdoor and indoor noise criteria for the kind of occupancy. For detailed design of noise control for services, specialist advice should be sought.

29.4.12.2 Control of noise from mechanical equipments can also be done by specifying noise control requirements while purchasing the equipments (see Appendix H).

APPENDIX ‘A’
(Clause 9.4.2.4)

NOISE CALCULATIONS

A-1 GENERAL
Some of the simpler types of noise calculation are described in this Annex.

A-2 ADDITION OF TWO NOISE LEVELS
To determine the combined sound pressure level (L_c) resulting from the sound pressure levels of two or more noise sources (L_1, L_2, etc), it is necessary to calculate and add the mean square values of their individual sound pressures and then convert this back to a
sound pressure level. This can be done using the following formula:

\[ L_c = 10 \log_{10} \left( 10^{L1/10} + 10^{L2/10} \right) \]

As the individual sound pressure levels are logarithms of the mean square sound pressures, they cannot simply be added arithmetically. Figure 3 shows a graphical method for adding the sound pressure levels from two independent sources to obtain the combined sound pressure level at a particular place. This graph may also be used for multiple sources by combining sources two at a time to produce virtual sources that can then be combined. The most accurate approach is to start with the lowest levels and work towards the highest.

The graph should be used with caution where the noise sources are not independent. For example, the sound pressure level from two large transformers fed with currents in phase will be very sensitive to the receiving position. This is because the effects of the constructive and destructive interference of the sounds from the two sources are very dependent on position.

### A-3 SUBTRACTION OF TWO NOISE LEVELS

When measuring noise from a source, the true noise level from the source alone will be less than that shown by the meter, if the level of extraneous noise is less than about 10Db below the total noise level. An estimate of the true source level can be obtained from Fig. 4.

### A-4 NON-UNIFORM COMPOSITE PARTITIONS

Figure 5 shows how to calculate the overall sound insulation of a composite partition consisting of two parts having different sound-insulating properties, for example a window in a wall. It may also be used to give an indication of the effect of gaps or holes in a partition by assigning a sound insulation value of 0 dB to the aperture.

### A-5 A-WEIGHTING CALCULATIONS

The equivalent A-weighting is often when data on a noise source is available as a set of octave band and or one-third octave band levels. The conversion can be done manually, using the standard A-weighting value (Table 10) and the graph for combining levels (Fig. 3). For all but the simplest situations it is more convenient to use a computer spreadsheet to do the conversion.
### Table 10 Standard A-Weighting Values (dB)

<table>
<thead>
<tr>
<th>Third Octave Band Center Frequency (Hz)</th>
<th>A-Weighting (dB)</th>
<th>Third Octave Band Centre Frequency (Hz)</th>
<th>A-Weighting (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>70.4</td>
<td>500</td>
<td>-3.2</td>
</tr>
<tr>
<td>12.5</td>
<td>-63.4</td>
<td>630</td>
<td>-1.9</td>
</tr>
<tr>
<td>16</td>
<td>-56.7</td>
<td>800</td>
<td>-0.8</td>
</tr>
<tr>
<td>20</td>
<td>-50.5</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>25</td>
<td>-44.7</td>
<td>1250</td>
<td>0.6</td>
</tr>
<tr>
<td>31.5</td>
<td>-39.4</td>
<td>1600</td>
<td>1.0</td>
</tr>
<tr>
<td>40</td>
<td>-34.6</td>
<td>2000</td>
<td>1.2</td>
</tr>
<tr>
<td>50</td>
<td>-30.2</td>
<td>2500</td>
<td>1.3</td>
</tr>
<tr>
<td>63</td>
<td>-26.2</td>
<td>3150</td>
<td>1.2</td>
</tr>
<tr>
<td>80</td>
<td>-22.5</td>
<td>4000</td>
<td>1.0</td>
</tr>
<tr>
<td>100</td>
<td>-19.1</td>
<td>5000</td>
<td>0.6</td>
</tr>
<tr>
<td>125</td>
<td>-16.1</td>
<td>6000</td>
<td>-0.1</td>
</tr>
<tr>
<td>160</td>
<td>-13.4</td>
<td>8000</td>
<td>-1.1</td>
</tr>
<tr>
<td>200</td>
<td>-10.9</td>
<td>10000</td>
<td>-2.5</td>
</tr>
<tr>
<td>250</td>
<td>-8.6</td>
<td>12500</td>
<td>-4.3</td>
</tr>
<tr>
<td>315</td>
<td>-6.6</td>
<td>16000</td>
<td>-6.6</td>
</tr>
<tr>
<td>400</td>
<td>-4.8</td>
<td>20000</td>
<td>9.3</td>
</tr>
</tbody>
</table>
Fig. 5 Sound Insulation of Non-Uniform Partitions
A-6 REVERBERATION TIME CALCULATIONS

An estimate of the reverberation time (T) of a room can be obtained the Sabine formula:

\[ T = \frac{0.16V}{\sum A_i} \]

where

- \( V \) = the volume of the room in cubic metres (m\(^3\));
- \( A_i \) = the equivalent sound absorbing area in the room in square metres (m\(^2\)).

The \( A_i \) are the absorbing areas of each surface, or other permanent fixture in the room. Each \( A_i \) is determined by multiplying the area of that surface in square metres by an absorption coefficient \( \alpha_{si} \). The surface of each significant fixture or feature of the room is to be considered as well as the walls, ceiling and floor.

The total absorption is obtained by summing the individual \( A_i \) values. As the values of \( \alpha_{si} \) are frequency-dependent, this calculation should be repeated for each octave band of interest.

An allowance should also be made for people and furnishings in the room.

APPENDIX ‘B’

(Clause 9.4.2.24, 9.4.2.38, 9.4.2.41, 9.4.2.50, 9.4.2.51, 9.4.2.52 and 9.4.2.53)

SPECIFICATION OF SOUND INSULATION

B.1 GENERAL

Sound insulating elements work mainly by reflecting sound energy back into the source room, not by absorbing it. The methods of measurement and the terms used are described in B-2 to B-4.

B-2 INSULATION AGAINST AIR-BORNE SOUND

As per the standard tests, the insulation between a pair of rooms is measured either in third octave bands having centre frequencies which cover at least the range 100 Hz to 3 150 Hz, or in octave bands which cover at lest the range 125 to 2 000 Hz. The noise is produced by a loudspeaker in one of the rooms (called the source room) and at each frequency the average noise levels are measured in the source room (\( L_S \)) and in the adjacent receiving room (\( L_R \)). The difference between these two levels (\( \Delta \)) is a measure of the sound insulation between the rooms regardless of the transmission path(s) the sound energy followed to travel between the rooms. The equation is as follows:

\[ D = L_S - L_R \]

The actual leveling of the receiving room depends on:

a) the sound insulation of the separating wall or floor;

b) the area of the separating wall or floor;

c) the volume of the receiving room;

d) the amount of flanking transmission (that is the importance of transmission paths other than the separating wall or floor); and

e) the amount of absorbing material (for example furniture) in the receiving room.

For field measurements, apart from the amount of absorption, these factors are a property of the building and should be taken into account by the measurement procedure. As the amount of absorbing material (for example soft furniture) in the room at the time of measurement is arbitrary, it should be allowed for separately. This is achieved by measuring the reverberation time (T) of the room in seconds (s), which is a measure of how long it takes a sound to die away after the source has been switched off. As the sound energy is dissipated as heat in the absorbing material (T), it is related to the total amount of absorption in the room. The receiving room level may then be corrected to the level it would be if the room had a standard reverberation time (\( T_o \)) which is typical of furnished rooms, and is taken to be 0.5 s. The corrected level difference is known as the standardized level difference, which has the symbol \( D_{nT} \) and is calculated using the following equation.

\[ D_{nT} = L_S - L_R + 10 \log_{10} (T/T_o) \]

For Laboratory measurements, the insulation of the separating wall or floor being tested is required in a way which is independent of the
actual measuring laboratory. For this reason, laboratories are designed to have minimal flanking transmission and a different correction is applied to account for the other factors. This correction is \(10 \log_{10} (S/A)\).

Where

\[
S = \text{the common area of the separating wall or floor in square metres (m}^2\text{)}; \text{ and}
\]
\[
A = \text{the equivalent absorption area in the receiving room in square metres (m}^2\text{)}.
\]

The laboratory corrected level difference at each frequency is known as the sound reduction index, which has the symbol \(R\) and is calculated using the following equation:

\[
R = L_S - L_R + 10 \log_{10} (S/A)
\]

If the test wall or floor is mounted in a realistic way in the laboratory and flanking transmission will be low in the field, the sound reduction index may be used to predict its performance in the field. The relation between \(D_{nT}\) and \(R\) is \(D_{nT} = R - 10 \log_{10} (3S/V)\).

Where

\[
S = \text{the area of the separating wall or floor in the field in square Metres (m}^2\text{)}; \text{ and}
\]
\[
V = \text{the volume of the receiving room in the field in cubic Metres (m}^3\text{)}.
\]

This equation shows that if the source and receiving rooms have different volumes, \(D_{nT}\) will depend on which is used as the source room; using the larger room as the source room will give lower value.

**B-3 INSULATION AGAINST IMPACT SOUND**

The procedure to measure the impact insulation of floors is rather different. Instead of a loudspeaker, a machine containing five small hammers is placed on the floor. While the hammers strike the floor at a rate of 10 blows a second, the resulting noise level (\(L_i\)) is measured in the receiving room below at each of the same frequency bands used for airborne insulation. In the field, the receiving room levels are again ‘corrected’ to a standard reverberation time (\(T_o\)) of 0.5 to give the standardized impact sound pressure level, \(L_{nT}\), which is calculated as follows:

\[
L_{nT} = L - 10 \log_{10} (T/T_o)
\]

In the laboratory, the noise level depends mainly on the characteristics of the floor being tested and the amount of absorption (\(A\ m^2\)) in the laboratory. It is therefore appropriate to correct the noise level to a standard area of absorption. The area used is 10 m². The resulting normalized impact sound pressure level is given the symbol \(L_n\) and calculated as follows:

\[
L_n = L_i + 10 \log_{10} (A/10)
\]

**B-4 RATING SOUND INSULATION**

Measurements of insulation against both airborne and impact sound yield values in a number of frequency bands. To make this information more manageable, rating methods such as those in accordance with IS 11050:1984, are used to reduce the frequency band values to single figure ratings. These single figure ratings should be good predictors of subjective assessments of insulation. However, this is not always the case and it is prudent to examine the full measurement data in critical situations. The impact insulation measured on a floor with a carpet is likely to be overestimated by this method.

The more common indices used to describe sound insulation are summarized in Table 11.

**Table 11 - Common indices used to describe air-borne and impact sound insulation**

(Clause B-4)
APPENDIX ‘C’
(Clause 9.4.2.22)

NOISE RATING

C-1 Noise rating (NR) is a graphical method of assigning a single number rating to a noise spectrum. It can be used to specify the maximum acceptable level in each octave band of a frequency spectrum, or to assess the acceptability of a noise spectrum for a particular application. The method was originally proposed for use in assessing environmental noise, but was later also found suitable for describing noise from mechanical ventilation systems in buildings. To make a rating, the noise spectrum is superposed on a family of NR contours; the NR of the spectrum corresponds to the value of the first NR contour that is entirely above the spectrum. The data for drawing NR contours (from NR 0 to NR 75) is given in Table 12 for the frequency range 31.5 Hz to 8 kHz.

C-2 For computational methods the curves are defined by the equation:

\[ L = a + bN \]

Where

\[ L \] is the octave band sound pressure level corresponding to NR level \( N \); and

\[ a \] and \[ b \] are constants for each frequency band, as given in Table 13.

NOTE – NR values cannot be converted directly to dBA Values but the following approximate relationship applies.

\[ NR = dBA - 6 \]

C-3 Although the NR system is currently the preferred method for rating noise from mechanical ventilation system, other methods which are more sensitive to noise at low frequencies are available, but they are not yet widely accepted. Low frequency noise may be disturbing or fatiguing to occupants, but may not have much effect on the dBA or NR value.

Table - 12 Noise Rating Values
(Clause C-1)
Forming spaces usually mean that more room has to be allocated for low velocity ventilation ductwork levels from electricity generating sets, construction equipment and HVAC utility equipment installed outdoors.

D-3 These regulations should be referred to by the designer for the design of measures for control of external noise.

APPENDIX ‘E’
(Clauses 3.8 and 4.5)

SPECIAL PROBLEMS REQUIRING EXPERT ADVICE

E-1 GENERAL

Certain design problems require reliable advice of a kind which is not easy to find in published material. The advice of an expert should be sought for these kinds of problems, some examples of which are given in E-2 to E-9.

E-2 ACOUSTIC TEST ROOMS

The design of rooms in which acoustic measurements are carried out, such as reverberation chambers, free-field anechoic rooms and audiometric test rooms, usually requires the advice of an expert.

E-3 PERFORMING SPACES

The design of theatres, opera houses, concert halls and similar performing spaces usually requires expertise in room acoustics and noise control. The intrusion of quite low levels of noise may seriously interfere with the enjoyment of the performance and distract the performers. The requirements for low noise levels often mean that more room has to be allocated for low velocity ventilation ductwork.

### Table – 13 Values of a and b
(Clause C-2)

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency Hz</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>35.4</td>
<td>0.681</td>
</tr>
<tr>
<td>125</td>
<td>22.0</td>
<td>0.870</td>
</tr>
<tr>
<td>250</td>
<td>12.0</td>
<td>0.930</td>
</tr>
<tr>
<td>500</td>
<td>4.2</td>
<td>0.980</td>
</tr>
<tr>
<td>1 000</td>
<td>0.0</td>
<td>1.000</td>
</tr>
<tr>
<td>2 000</td>
<td>-3.5</td>
<td>1.015</td>
</tr>
<tr>
<td>4 000</td>
<td>-6.1</td>
<td>1.025</td>
</tr>
<tr>
<td>8 000</td>
<td>-8.0</td>
<td>1.030</td>
</tr>
</tbody>
</table>

### APPENDIX ‘D’
(Clause 9.4.3.3)

OUTDOOR NOISE REGULATIONS IN GHANA

D-1 Government notifications are issued form time-to-time on the allowable ambient noise levels in general and specifically in different zones of various metropolitan cities of India.

D-2 Noise regulations and notifications are also issued from time-to-time specifying the maximum permissible sound levels from equipments commonly used in and around the residential areas and around sensitive buildings, specifically with regard to noise levels from electricity generating sets, construction equipment and HVAC utility equipment installed outdoors.
and the impact on the design of the ventilation system is often substantial.

E-4 BROADCASTING AND RECORDING STUDIOS

Broadcasting and recording studios have requirements similar to those of performing spaces. For some infrequent intrusive noises, the requirements are sometimes relaxed on the grounds that a re-take of a recording can be done, but this can result in higher operating costs.

E-5 AIRCRAFT NOISE

As there are many variables affecting the level of aircraft noise heard on the ground, expert advice is almost always required. Contours of daytime $L_{Aeq,T}$ levels are available from most major airports. Where measurements of façade insulation are necessary a standard test method may be preferred.

E-6 GROUND-BORNE NOISE

Projects involving ground-borne noise from underground trains usually require expert advice.

E-7 LOW-FREQUENCY NOISE

Projects involving low-frequency noise usually require expert advice as accurate measurement is difficult and there is a shortage of reliable data below 100 Hz.

E-8 ACTIVE NOISE CONTROL

Active noise control is the reduction of noise by cancellation with a similar noise (anti-noise) generated by electro-acoustic means. The technique is still under development, but commercial systems are available which successfully reduce low frequency noise from mechanical ventilation systems.

E-9 NOISE SURVEYS

Noise surveys are carried out for a variety of reasons, for example.

a) before construction, to establish the existing noise climate at the site of a proposed development where reliable prediction is impracticable, as an aid to the design of the building envelope, either to protect against external noise or contain internally produced noise;

b) during construction, to monitor noise from building activity, either to assess the likely nuisance to the local community or the risk of hearing damage to the work force;

c) at the end of a building contract to check the insulation of the building envelope, or the noise levels produced by the services;

d) as part of a planning requirement; and

e) to provide objective evidence to support or defend a legal action.

The expense of carrying out a comprehensive noise survey of any kind is likely to be high, so the cost-effectiveness of a full or partial survey should be weighed against alternatives such as prediction. A survey will generally be more accurate and can take account of factor such as prevailing wind conditions.

APPENDIX ‘F’

(Clause 9.4. 4.4)

AIR-BORNE AND IMPACT SOUND INSULATION

F-1 GENERAL

Air-borne sound refers to sources which produce sound by directly setting the air around them into vibration. Impact sound refers to sources which produce sound by impulsive mechanical excitation of part of a building (for example by footsteps, electric light switches, slamming doors). Many sources of impact sound also produce significant levels of airborne sound. The term structure-borne sound has no very precise meaning as the structure can be excited by both airborne and impact sources; it is often used to refer to sound that travels for long distances via the structure, especially in connection with vibrating machinery linked directly to the structure.

F-2 DIRECT AND INDIRECT TRANSMISSION

Figure 6 shows diagrammatically a pair of rooms in a house where the construction consists of solid walls, etc. bonded together. Sound traveling from room 1 to room 2 may travel via the direct path a-a and by the many indirect, or flanking paths shown. The term
flanking transmission is usually used to mean transmission paths involving the structure, while the term indirect transmission includes flanking paths and airborne paths through gaps and ducts, etc. The indirect paths may limit the sound insulation attainable no matter how much the direct sound is reduced by the separating wall or floor. The indirect transmission can be reduced by measures such as the following:

a) Increasing the mass of the flanking walls;
b) Increasing the mass of the partition and bonding it to the flanking walls;
c) Introducing discontinuities in the indirect paths;
d) Erecting independent wall linings adjacent to the flanking walls to prevent energy entering the flanking construction; and
e) Sealing any air gaps and paths through ducts.

Figure 7 shows a number of indirect paths that have been found in offices.

It is important to remember that standard test laboratories are designed to minimize transmission by all paths other than the direct path. This makes it difficult to relate the results of laboratory measurements to those likely to be obtained in the field.
Fig. 6 Transmission Paths (Via the Structure) of Noise Originating in Room 1 (Diagrammatic)
F-3 AIR-BORNE SOUND INSULATION

F-3.1 General

The sound insulation of structural elements such as walls and floors always varies with frequency, the insulation rising in general as the frequency rises.

F-3.2 Terminology

Results from field measurements are usually expressed in terms of the weighted standardized level difference, while laboratory measurements are usually expressed in terms of the sound reduction index. In the absence of significant flanking transmission, the numerical difference between the weighted standardized level difference and the sound reduction index of a wall or floor is usually small for furnished rooms in dwellings, and so either quantity may be used in considering principles; for this purpose it is, therefore, convenient to use the general term insulation.

F-3.3 Mass law

An approximate empirical relationship has been established between sound insulation and mass for single leaf constructions as shown in Fig. 8. This so-called 'mass law' gives a useful first approximation to the behaviour of a single sheet or plate. In
practice, the sound insulation predicted by the mass law may not be attained because of factors such as the coincidence effect, which is outlined in F-3.4. Results for specific materials vary around the value given by the mass law relationship, and so measured data should be used when available. Table 14 gives a lists of materials and indicates the sound insulation of a single, imperforate sheet when fixed to a suitable wood or metal framework. These values are useful, for example when assessing existing structures.

![Graph showing sound insulation vs surface mass](image)

**Table 14 - Sound insulation of Imperforate Sheet Materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Surface Mass (Kg/m²)</th>
<th>Typical Weighted Sound Reduction Index, $R_w$ (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 mm glass sheet</td>
<td>7.0</td>
<td>26</td>
</tr>
<tr>
<td>12.5 mm plasterboard</td>
<td>10.5</td>
<td>31</td>
</tr>
<tr>
<td>18 mm wood particle board</td>
<td>8.0</td>
<td>27</td>
</tr>
<tr>
<td>19 mm plywood</td>
<td>3.0</td>
<td>24</td>
</tr>
<tr>
<td>16 mm plywood</td>
<td>4.5</td>
<td>24</td>
</tr>
<tr>
<td>1 mm steel sheet</td>
<td>11.0</td>
<td>29</td>
</tr>
<tr>
<td>6 mm hardboard</td>
<td>5.0</td>
<td>25</td>
</tr>
<tr>
<td>12 mm wood fibre insulation board</td>
<td>4.0</td>
<td>24</td>
</tr>
<tr>
<td>13 mm mineral fibre board</td>
<td>4.0</td>
<td>24</td>
</tr>
<tr>
<td>50 mm wood-wool screeded one side</td>
<td>35.0</td>
<td>33</td>
</tr>
</tbody>
</table>

### F-3.4 The Coincidence effect

The coincidence effect occurs when the wavelength of the wave impressed on the panel by the incident sound wave is close to the wavelength of free bending waves in the panel. The effect of coincidence is to lower the sound insulation of a construction by as much as 10 dB below the level expected from its mass per unit area over a limited frequency range. The coincidence effect can be pronounced with thin lightweight partitions, resulting in loss of insulation at middle and high frequencies. Reducing the stiffness without a corresponding reduction of mass can
raise the critical frequency above 3 150 Hz, and so improve the insulation over the important 100 Hz to 3 150 Hz range. An increase of stiffness will have the reverse effect.

It is possible to design lightweight stud partitions so that they perform to their maximum effect in the speech frequency region between 250 Hz and 2 000 Hz, that is between the mass-spring mass and coincidence regions respectively.

The worst coincidence dips occur in materials such as plate glass and rigid metal sheets. Heavily damped materials such as lead sheets are least affected.

F-3.5 Mass-spring-mass frequency
A double leaf wall can perform better than a single leaf wall of similar mass because the sound has to pass through two barriers. If the two leaves are not connected to each other, the insulation values of the two leaves may be added together. However, in practice the leaves are often connected by ties or studs, and the full insulation cannot be achieved. Even where the two leaves are isolated from each other, the full benefit can only be obtained above a certain frequency that depends on the cavity width. This is because the air in the cavity behaves like a spring connecting the leaves together, and causes a resonance at the mass-spring-mass frequency. Below this frequency, the two leaves behave more like an equivalent single leaf.

Making the cavity width can reduce the mass-spring frequency, as in the case of sound insulating secondary glazing. The mass-spring-mass frequency ($F_{0}$) may be estimated from the following equation:

$$F_{0} = 59.6 \sqrt{\frac{1}{d} \left( \frac{1}{m_1} + \frac{1}{m_2} \right)}$$

Where $m_1$ and $m_2$ = the surface masses of the two leaves in kilograms per square metre (kg/m²); and $d$=the cavity width in metres (m).

F-3.6 Impact sound control
A structure that receives an impact or has a vibrating source in contact with it behaves more like an extension of the source rather than an intervening element between source and listener. For this reason, a relatively small amount of impact energy may produce a loud sound and, if the structure is continuous, the sound may travel a long distance. Control is usually obtained by inserting a resilient surface at the point of contact with the source (for example laying a carpet on a floor) or by introducing a structural discontinuity.

Floating floors, which are an example of the latter approach, are a common method of controlling impact sound from footsteps. However, it should be noted that an effective floating floor may result in increased sound from impacts on the source side of the floor. The conventional forms of floating floor may be unsatisfactory if protection against the low-frequency content of impact noise is required (e.g. a dance floor over a restaurant).

F-4AIR-BORNE INSULATION VALUES OF WALLS AND AIR-BORNE AND IMPACT INSULATION VALUES OF FLOORS
Table 15 and Table 16 give examples of common types of wall and floor construction with sound insulation in the ranges shown. The insulation indices are for field measurements accessed in accordance with [8-4(5)]. The insulation values given are necessarily approximate since examples of normally identical constructions may show variations of several decibels. All the figures represent values expected in the field, that is, in actual buildings. Many are based directly on field measurements, though others (in the absence of representative field measurements) have been assessed from laboratory data, with an allowance for typical flanking conditions in normal buildings. Variation in the amount of indirect transmission may affect significantly the insulation between two rooms separated by a given barrier. For example, the sound insulation of some types of floor may be reduced by indirect transmission along the walls supporting them, particularly if these walls are of lightweight masonry and carried past the floor.

### Table 15 - Air-borne sound insulation of walls and partitions
(Clauses F-4)

<table>
<thead>
<tr>
<th>Sound Insulation</th>
<th>Type of wall or partition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1077
<table>
<thead>
<tr>
<th>$D_{n,T,w}$ (dB)</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 to 33</td>
<td>a) 1mm steel sheet panels fixed to steel frame members to form demountable partition units 50 mm overall thickness. Mineral wool cavity insulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Plywood or wood fibre board 12mm thick nailed both sides of 50mm x 50mm timber framing members spaced at 400 mm centres.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Paper faced strawboard or wood wool 50mm thick panels plastered both sides.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Chipboard hollow panels 50mm thick tongued and grooved edges, hardboard faced. Joints covered with wood trim.</td>
<td></td>
</tr>
<tr>
<td>33 to 37</td>
<td>a) Lightweight masonry blockwork. Plaster or drylining on at least one side. Overall mass per unit area not less than 50 kg/m².</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Laminated plasterboard at least 50mm thick fixed to timber perimeter framing, any suitable finish. Approximate mass per unit area 35 kg/m².</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Timber stud partitions may size timbers greater than 50 mm x 50 mm, 400mm centres, cross noggins, 9.5 mm plasterboard lining on both sides, any suitable finish.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Metal stud partition, 50mm studs 600mm centres, clad both sides with 12.5 mm plasterboard, joints filed and perimeters sealed. Approximately mass per unit area 18 kg/m².</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) 50 mm lightweight masonry blockwork, plastered both sides to 12mm thickness or drylined with 9.5mm plasterboard.</td>
<td></td>
</tr>
<tr>
<td>37 to 43</td>
<td>a) Lightweight masonry blockwork, plaster or dry lining on at least one side. Overall mass per unit area not less than 75 kg/m².</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Either 75mm or 100 mm x 50 mm timber studs spaced 600 mm apart, 50 mm mineral fibre quilt in stud cavity. Frame lined on both sides with one layer 12.5 mm plasterboard. Approximate mass per unit area 19 kg/m².</td>
<td></td>
</tr>
<tr>
<td>43 to 50</td>
<td>a) Masonry wall, joints well filled. Either plaster or dry lining on both sides. Overall mass per unit area not less than 150 kg/m².</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) 100mm metal stud partition, ‘C’ clause studs not greater than 600 mm spacing, not less than nominal 50mm web depth. Clad on both sides with two layers of plasterboard of not less than 22mm combined thickness. Mineral fibre quilt hung between studs. Approximate mass per unit area 35 kg/m².</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) 75 mm x 50mm timber framing using staged studs at 300 mm spacing.</td>
<td></td>
</tr>
</tbody>
</table>
spacing with 25 mm staf fer forward and back. Frame clad with two layers of 12.5 mm of plasterboard on both sides. Mineral fibre quilt hung between studs. Approximate mass per unit area 36 kg/m².

d) 50 mm x 25 mm timber stud partition to form a 25 mm cavity, clad on both sides with minimum 38 mm wood wool slabs having their outer faces screeded or plastered.

e) Solid autoclaved aerated concrete block 215 mm thick plaster or dry lined finish on both sides, blockwork joints well filled. Overall mass per unit area not less than 160 kg/m².

50 to 54

(a) Two separate frames of timber studs not less than 89 mm x 38 mm, or boxed metal studwork with 50 mm minimum web depth. Studs at 600 mm maximum centres. A 25 mm mineral wool quilt suspended between frames. Frames spaced to give a minimum 200 mm overall cavity. Clad on outside of each frame with a minimum of 30 mm plasterboard layers (for example 19 mm plus 12.5 thickness). Approximate mass per unit area 54 kg/m².

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>Either in-situ or pre-cast concrete wall panel not less than 175 mm thick and not less than 415 kg/m². All joints well filled.¹</td>
</tr>
<tr>
<td>(c)</td>
<td>Brick wall nominal 230 mm thickness, weight (including plaster) not less than 380 kg/m². Plaster or dry-lined finish both sides. Brickwork joints well filled.¹</td>
</tr>
<tr>
<td>(d)</td>
<td>‘No fines’ concrete 225 mm thickness, weight (including plaster) not less than 415 kg/m². Plaster or dry-lined finish both sides.¹</td>
</tr>
<tr>
<td>(e)</td>
<td>Cavity lightweight aggregate block (maximum density of block 1600 kg/m³) with 75 mm cavity and wall ties of the butterfly wire type. Dry lined finish or both sides. Joints in blockwork well filled. Overall mass per unit area not less than 300 kg/m².¹</td>
</tr>
<tr>
<td>(f)</td>
<td>Dense aggregate concrete block cavity wall with 50 mm cavity and wall ties of the butterfly wire type. Dry lined finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 415 kg/m².¹</td>
</tr>
<tr>
<td>(g)</td>
<td>Autoclaved aerated concrete block cavity wall consisting of two leaves, 100 mm blocks not less than 75 mm apart, with wall ties of the butterfly type. Plaster or dry line finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 150 kg/m².¹</td>
</tr>
</tbody>
</table>

54 to 60

(a) Two separate frames of timber studs not less than 100 mm x 50 mm spaced at 600 mm maximum centres. A 50 mm mineral wool quilt in each frame between studs. Frames spaced to give a minimum 300 mm overall cavity. Each frame clad on outside with three layers of 12.5 mm plasterboard nailed to framing. Approximate mass per unit area 51 kg/m².¹

(b) Two separate frames of boxed ‘C’ clause galvanized nominal 150 mm steel studs 100 mm apart with a 400 mm overall cavity. 50 mm mineral wool quilt fixed to the back of one frame each frame clad on outside with three layers of 12.5 mm
plasterboard by self drilling or tapping screws. Approximate mass per unit area 47 kg/m².\(^1\)

(c) Solid masonry with an overall mass per unit area of not less than 700 kg/m² fully sealed both sides. \(^1\)

(d) Dense aggregate concrete block solid wall 215mm thick plaster finish to both surfaces. Overall mass per unit area not less than 415 kg/m². \(^1\)

\[\begin{array}{l}
\text{(1)} \\
\text{(2)} \\
\hline \\
(e) \text{Cavity lightweight aggregate block (maximum density of block 1 600 kg/m}^3\text{) with 75mm cavity and wall tiles of the butterfly wire type. Plaster finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 300 kg/m}^2. \(^1\) \\
(f) \text{Density aggregate concrete block cavity wall with 50mm cavity and wall ties of the butterfly wire type. Plaster finish on both sides. Joints in blockwork well filled. Overall mass per unit area not less than 445 kg/m}^2. \(^1\)
\end{array}\]

Notes
1 Construction details and workmanship are important if the levels of sound insulation indicated are to be achieved.

2 Where plasterboard is specified it is assumed that the surface mass will be at least 6.5 kg/m² for 9.5mm thick board, at least 8.5 kg/m² for 12.5mm thick board, and at least 14.5 kg/m² for 19mm thick board. If less dense plasterboard is used, the thickness should be increased.

\(^1\) When considering these constructions for separating walls, expert advice should be sought.

Table 16 - Air-borne and impact sound insulation of floor construction
(Clause F-4)

<table>
<thead>
<tr>
<th>Sound Insulation dB</th>
<th>Type of Wall or Partition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D_{\text{nT},w} = 49) to 54</td>
<td>a) A concrete floor having mass per unit area not less than 365 kg/m², including any screed or ceiling finish directly bonded to the floor slab; together with a floating floor or resilient floor covering equivalent to rubber or sponge rubber underlay or thick cork tile (for example carpet and underlay or sponge rubber backed vinyl flooring).</td>
</tr>
<tr>
<td>(L'_{\text{nT},w} = 56) to 65</td>
<td>b) A solid floor consisting of:</td>
</tr>
<tr>
<td></td>
<td>1) a solid slab; or</td>
</tr>
<tr>
<td></td>
<td>2) concrete beams and infilling blocks; or</td>
</tr>
<tr>
<td></td>
<td>3) hollow concrete planks, together with a floating floor.</td>
</tr>
<tr>
<td></td>
<td>A ceiling finish is required for a beam and block floor. In each case the slab should have a mass per unit area of at</td>
</tr>
</tbody>
</table>

1080
Where a floating floor is laid over a floor of beams and hollow infill blocks or hollow beams along the top of the structural floor, it should be sealed and leveled before the resilient layer is put down. It is also essential to have due regard for conduits and pipework which should be laid and covered so as to prevent any short circuit of the floor's isolating properties.

The resilient material is laid to cover completely the structural floor and turned up against the surrounding wall along all edges. The resilient layer is usually of mineral fibre, or a special grade of expanded polystyrene. When the screed is laid, it is important that none of the mix finds its way through the resilient layer to the structural floor, as this will short circuit the isolation between the two decks and significantly reduce the sound insulation.

A floor consisting of boarding nailed to battens laid to float upon an isolating layer of mineral fibre capable of retaining its resilience under imposed loading. With battens running along the joists, a dense fibre layer can be used in strips.

<table>
<thead>
<tr>
<th>Sound Insulation dB</th>
<th>Type of Wall or Partition</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_{nT,w} = 32 to 36</td>
<td>A floor consisting of 18mm tongued and grooved chipboard on 19mm plasterboard laid on battens running parallel to the joists and supported on 25 mm thick mineral wool of about 90 kg/m^3 to 140 kg/m^3 density; 100mm of fibre absorbent (as used for insulation in roof spaces) laid between the joists on top of the plasterboard ceiling.</td>
</tr>
<tr>
<td>L'_{nT,w} = 80 to 85</td>
<td>A floor consisting of 18mm tongued and grooved chipboard on 19mm plasterboard floating on a 25mm thick mineral wool layer of about 60 kg/m^3 to 80 kg/m^3 density; this on a 12.5mm plywood platform; 100mm of fibre absorbent laid between the joists on top of the plasterboard ceiling.</td>
</tr>
</tbody>
</table>

Timber joist floor consisting of 22mm tongued and grooved floor boarding or equivalent fixed directly to floor joists. Ceiling of 12.5mm plasterboard and skim with no floor covering.

Notes
1 Construction details and workmanship are important if the levels of sound insulation indicated are to be achieved.
2 Where plasterboard is specified it is assumed that the surface mass will be at least 8.5 kg/m^2 for 12.5mm thick board, and at least 14.5 kg/m^2 for 19mm thick board. If
less dense plasterboard is used, the thickness should be increased.

In these types of floor construction, the ceiling may be 19mm plus 12.5mm plasterboard. It is imperative that the resilient layer is not punctured by nails.

In many cases, simple solid partition give insulation values according to their mass (see F-3.3). Moreover, with partitions of this type there is usually little variation between field and laboratory test results unless the laboratory insulation exceeds 45 dB. Exceptions may occur in buildings that have not been specially designed to minimize common cavities and strongly coupled elements in lightweight paneling. The examples given are not exhaustive. Flanking structures are not listed since these can vary widely and are often dependent upon other factors such as thermal insulation, which are outside the scope of this Code.

APPENDIX ‘G’
(Clause 9.4.13.1)
BASIC DESIGN TECHNIQUES FOR NOISE CONTROL IN AIR CONDITIONING, HEATING

G-1 When selecting fans and other related mechanical equipment and when designing air distribution systems to minimize the sound transmitted from different components to the occupied spaces that they serve, the following recommendations should be considered:

a) Design the air distribution system to minimize flow resistance and turbulence. High flow resistance increases the required fan pressure, which results in higher noise being generated by the fan. Turbulence increases the flow noise generated by duct fittings and dampers in the air distribution system, especially at low frequencies.

b) Select a fan to operate as near as possible to its rated peak efficiency when handling the required quantity of air and static pressure.

APPENDIX ‘H’
(Clause 9.4.13.2)
SUGGESTED EQUIPMENT NOISE DATA SHEET

It is recommended that an equipment noise data sheet be furnished to intended bidders of mechanical equipment such as air-conditioning, heating and mechanical ventilation machinery or diesel generation units specifying noise requirements at the time of request for quotation. Following is a sample noise data sheet suggested for the purpose:
29.5 GAS SUPPLY
For Gas supply, installation and inspection shall comply with Ghana Standards.

29.5.1 Scope
This clause covers the requirements regarding the safety of persons and property for all piping uses and for all types of gases used for fuel or lighting purposes in buildings. This Clause does not cover safety rules for gas burning appliances.

29.5.2 Definitions
For the purpose of this Clause, the following definitions shall apply:

Appliance valve – A device that will shut-off the gas supply to the burner(s).

Authority having jurisdiction – The Authority which has been created by a statute and which, for the purpose of administering the Code/Part, may authorize a committee or an official to act on its behalf; hereinafter called the ‘Authority’.

Customer’s/Consumer’s connection – Piping tapped on riser to supply each individual customer/consumer.

Gas fitter – An employee of the gas supplying organization.

Pipplot – A small flame which is utilized to ignite the gas at the main burner(s).

Pressure regulator – A device designed to lower the pressure of gas coming from the distribution main and to maintain it practically constants downstream. This normal operation pressure shall be practically in all cases that of the gas appliances used.

Purge – To free a gas conduit of air or gas or a mixture of gas and air.

Qualified installing agency – An individual, firm or agency which either in person or through a representative is engaged in and is responsible for the installation or replacement of gas piping on the outlet side of the gas supply piping and appliances within a building, and who is experienced in such work, familiar with all precautions required, and who has complied with all the requirements as to qualification, registration, licensing, etc. of the Authority.

Riser – Piping usually vertical on most of its length that supplies gas from the service to the various storeys of the building.

Service pipe – Pipe that runs between the distribution main in the street and the riser in the case of multi-storey building or the meter in the case of an individual house.

Service shut-off valve (isolation valve)
A device installed outside the premises to cut-off the main supply of gas from pipeline by the supplier.

Vent pipe – A safety device to which certain regulators are connected to evacuate outside gas that may escape from the normal circuit when some part of system gets damaged or malfunctions or a safety valve is open.

29.5.2 Pressure regulations

29.5.2.1 Pressure regulation is required to economize the sizing of piping system. Where the pressure of gas supplied to domestic system or other low pressure gas piping system in buildings is in excess of the pressure to be used in the appliance, a gas pressure regulator of suitable specification shall be installed in service pipe of each system to prevent excess pressure reaching the appliance. The pressure regulators to be used can be from 400 kN/m² upstream pressure to 2.1 kN/m² for domestic consumers and 10 kN/m², 30 kN/m², 200 kN/m² for commercial consumers, as the case may be.

29.5.2.1.1 In some place the reduction of pressure from main distribution source of 400 kN/m² to intermediate pressure (say 7 kN/m²) and then to operating pressure of 2.1 kN/m² is achieved.

29.5.2.1.2 Where as in most of the other places the reduction of pressure from main distribution source of 400 kN/m² to directly operating pressure (say 2.1 kN/m², 10 kN/m², 30 kN/m², 200 kN/m²) is achieved in single stage pressure reduction.

29.5.2.2 If located inside a building, the required regulator shall comply with the following:

a) If any of the diaphragms of the regulator ruptures, the gas shall be sent to an outlet vent pipe made of brass or plastic in order...
to ventilate or drain the gas out of the building. The vent pipe will, however, lead to outer air about 1m above the topmost storey of the building. Means shall be employed to prevent water from entering this pipe and also to prevent stoppage of it by insects or other foreign bodies.

b) If the gas pressure at the outlet of the regular falls below 50 percent of the operating gas pressure or rises above twice the operating gas pressure, the gas input to the pressure regulator shall be cut off.

c) In the event of malfunctioning of this safety device, a supplementary device shall connect the low pressure circuit to the outlet circuit (vent pipe) as soon as the exit pressure reaches 7 kN/m$^2$.

29.5.2.3 It shall also be ensured by the supply authority that the calorific value and supply pressure of gas shall not exceed the values for the type of gas used.

29.5.3 Service shut-off valves

29.5.3.1 Service shut-off valves shall be installed on all new services including replacements in a readily accessible location.

29.5.3.2 Service shut-off valves shall be located upstream of the meter if there is no regulator or upstream of the regulator, if there is one.

29.5.3.2.1 Service shut – off valves shall be located in the upstream of the meter, if a single regulator is supplying more than one consumer and each such stream shall have one additional shut off valve upstream of regulator.

29.5.3.3 All gas services operating at pressure greater than 7 kN/m$^2$ shall be equipped with an approved service shut-off valve located on the service pipe outside the building.

9.7.4.4 Underground shut-off valves shall be located in a covered durable curb box, manhole, vault or stand pipe which is designed to permit ready operation of the valve and the covers of which shall be clearly marked ‘Gas’.

29.5.4 Existing work

Nothing herein shall prohibit the continued use of existing system of the gas piping without further inspection or test, unless the Authority has reason to believe that defects which make the system dangerous to life or property exist.

29.5.5 Rules for turning gas on

29.5.5.1 No person, unless is the employ of the gas company or having permission from the gas company, shall turn on the gas at a service shut-off valve or at any valve that controls the supply of gas to more than one consumer.

29.5.5.2 Gas shall not be turned on at any meter valve without specific permission from the gas company or other authority if any of the following conditions exists.

a) If the gas piping appliances or meter supply through the meter valve are known to leak or otherwise to be defective (see 10).

b) If required inspection of the piping or appliance has not been made.

c) If the gas company or other authority has requested that the gas be left turned off.

d) If the meter valve is found shut off for some reason not known to the gas fitter.

The gas shall not be turned on in the event of fire.

29.5.5.3 Gas shall not be turned on at any branch line valve if any of the conditions specified in this Code prevails. Where a branch line valve is found closed, a gas fitter shall again turn the gas on at such valve only if proper precautions to prevent leakage are taken and no other unsafe conditions are created thereby.

29.5.5.4 Gas shall not be turned on at either the meter valve or service line unless all gas keys or valves provided on all outlets in the piping system are closed or all outlets in the piping system are capped or plugged.

29.5.6 Rules for shutting off the gas

29.5.6.1 The gas fitter shall put the gas off to any appliance, pipe or piping system and shall leave the gas turned off, until the causes for interrupting the supply has been removed in any one of the following cases:

a) If ordered to do so by the Authority.
b) If leakage of gas is noted, which appears to be sufficient to cause fire, explosion or asphyxiation

c) If an installation of some gas appliance is found to be such as to cause a serious hazard to persons or property.

d) If any condition exists which threatens interruption of gas supply which may cause burner outage or otherwise prove dangerous.

29.5.6.2 It shall be the duty of the installing agency when the gas supply is to be turned off to notify all affected consumers.

29.5.6.3 Before turning off the gas at the meter, for the purpose of installation, repair, replacement or maintenance of piping or appliance, all burner and pipplot valves on the premises supplied with gas through the meter shall be turned off and the meter test hand observed for a sufficient length of time to ascertain that there is no gas passing through the meter. Where there is more than one meter on the premises, precaution shall be exercised to ensure that the concerned meter is turned off.

29.5.7 Installation of gas pipes

29.5.7.1 Installation, repair and replacement of gas piping or appliances shall be performed only by a qualified installing agency.

29.5.7.2 Piping

29.5.7.2.1 Piping shall be of wrought iron, steel, copper or cast iron when the gas pressure is less than 7kN/m², with higher gas pressure e use of cast iron shall be prohibited.

29.5.7.2.1.1 SS 316/304/321 Flexible PE coated flexible pipe in rolls shall be permitted in low pressure system provided the pipe meets the required standard, to avoid the bends, fitting and leakages from the joint which are potential leakage points. Also reference may be made to accepted standard. Heavy rubber flexible tube shall be permitted only as direct connection to burner form appliance valve.

29.5.7.2.2 Size of Gas piping

Gas piping shall be of such size and so installed as to provide supply of gas sufficient to meet the maximum demand without undue loss of pressure between the meter or service regulator when a meter is not provided, and the appliance(s).

29.5.7.2.2.1 The size of gas piping depends upon the following factors:

a) Allowable loss in pressure from meter or service regulator, when a meter is not provided to appliance;

b) Maximum consumption to be provided;

c) Length of piping and number of fittings and

d) Specific gravity of gas

29.5.7.2.2.2 No gas pipe smaller than 8 mm shall be used.

29.5.7.2.3 As far as possible, straight lengths of piping should be used. Where there are bends in the pipe line, these should have a radius of at least five times the diameter of the pipe.

29.5.7.2.4 For any thread joint proper sealant shall be used on male threads only.

29.5.7.3 The gas piping shall be of the colour stipulated by explosive authority to distinguish it from other piping and the piping shall be painted silver grey with read band of 150mm width. The gas pipeline shall be painted canary yellow in case of natural gas.

29.5.7.4 Piping underground

29.5.7.4.1 Protection of piping

Piping shall be buried to a minimum depth of 1m or covered in a manner so as to protect the piping from physical damage.

29.5.7.4.2 Protection against corrosion

Generally, all the piping within the premises where it has to run on the wall shall be exposed and should not be in contact with a wall to ensure that no corrosion takes place. Epoxy sealant or polyethylene conduit shall be used to ensure no contact of pipe with the wall in the situation of pipe crossing the wall. Under ground or concealed gas pipeline in contact with earth or other materials which may corrode the piping shall be protected against corrosion by application of adequate corrosion resistant coating backed up by cathodic protection system.

29.5.7.5 The building shall not be weakened by the installation of any gas piping.

29.5.7.6 Gas piping in building shall be supported with pipe hooks, metal pipe straps, bonds or hangers suitable for the size of piping
and of adequate strength and quality and located at proper intervals so that the piping may not be moved accidentally from the installed position.

29.5.7.7 Pipe entrance to buildings

Where gas pipe enters a building through a wall or floor of masonry or concrete, any gas piping or other piping entering the walls or floors shall be suitably sealed against the entrance of water/moisture or gas. Regarding protection of openings in walls or floors, from fire, reference shall be made to Part 3: Use and Occupancy Classification.

29.5.7.7.1 Piping in floors

Piping in solid floors, such as concrete, shall be laid in channels in the floors suitably covered to permit access to the piping with a minimum damage to the building.

29.5.7.7.2 Single pipe without joint shall be used for wall crossing in any building.

29.5.7.8 Gas pipe shall not be bent. Fittings shall be used when making turns in gas pipe.

29.5.7.9 Generally concealed piping shall not be allowed. However, if it is necessary then it shall be under the Clause 29.5.7.4 of underground piping and all protection such as coating, cathodic protection shall be done.

29.5.7.10 A drip shall be provided in the gas distribution system, if the moisture contents in the gas is likely to reach saturation point at any stretch of pipe line in the system; a drip shall, however, be provided at any suitable point in the line of the pipe where condensate may collect and from where it can be easily removed. This drip should be so installed as to constitute a trap where in an accumulation of condensate will shut off the flow of gas before it will run back into the meter.

29.5.7.10.1 Drip has to be provided in the case of gas consisting moisture content.

29.5.7.11 Prohibited devices

No device shall be placed inside the gas piping or fittings that will reduce the cross-sectional area or otherwise obstruct the free flow of gas.

29.5.7.12 Piping shall be electrically continuous throughout its length and property earthed except in stretches where cathodic protection system is used for protection against corrosion. It shall not, however, be used to earth any electrical equipment.

29.5.7.12.1 The distance between gas piping and electrical wiring system shall be at least 60 mm and, where necessary, they shall be securely fixed to prevent contact due to movement. The gas piping should run above the electrical wiring. In this type of installation in the event of any leakage of natural gas, the gas would move up (natural gas being lighter than air) and would not come directly in contact with the electrical wiring. If the gas to be supplied is heavier than the air then the gas piping should run below the electrical wiring.

29.5.7.13 The distance between the gas piping and steam piping, if running parallel, shall be at least 150 mm. The gas piping should preferably run below the steam piping.

29.5.7.14 Piping installation shall be thoroughly gas-tight.

29.5.7.15 Smoking shall not be permitted when working on piping which contains or has contaminated gas.

29.5.7.16 Meters shall be installed in such a way that there shall be no load transfer from the pipeline to the inlet/outlet of the meter and shall be easily accessible.

29.5.8 Inspection of services

29.5.8.1 No person shall use or permit the use of a new system or an extension of an old system of gas piping in a building or structure before the same has been inspected and tested to ensure the tightness of the system, and a certificate has been issued by the Authority.

29.5.8.1.1 Test of Piping for Tightness

Before any system of gas piping is finally put in service, it shall be carefully tested to ensure that it is gas-tight. Where any part of the system is to be enclosed or concealed, this test should precede the work of closing in. To test for tightness the piping may be filled with city gas, air or inert gas but not with any other gas or liquid. In no case shall oxygen be used. The piping shall stand a pressure of at least 20 kN/m² measured with a manometer or slope gauge, for a period of not less than 10 min without showing any drop in pressure.

29.5.8.1.2 When the gas pressure exceeds 7 kN/m², the piping shall withstand a pressure of 0.6 MN/m² for 3 h. (This test is for piping
designed for working pressure less than 0.4 MN/m².

29.5.8.2 The Authority shall, within a reasonable time after being requested to do so, inspect and test a system of gas piping that is ready for such inspection and test, and if the work is found satisfactory and test requirements are complied with, it shall issue the certificate.

29.5.9 Leakage check

29.5.9.1 Before turning gas under pressure into any piping; all openings from which gas may escape shall be closed.

29.5.9.2 Checking for gas leakage

No matches, flame or other sources of ignition shall be employed to check for gas leakage from meters, piping or appliances. Checking for gas leakage with soap and water solution is recommended.

29.5.9.3 Use of lights

Artificial illumination used in connection with a search of gas leakage shall be restricted to electric hand flash lights (preferably of the safety type) or approved safety lamps. In searching for leaks, electric switches should not be operated. If electric lights are already turned on, they should not be turned off.

29.5.9.4 Checking for leakage with meter

Immediately after turning gas into the piping, the system shall be checked to ascertain that no gas is escaping. This may be done by carefully watching the test dial of the meter to determine whether gas is passing through the meter. In no case should a leakage test be made using a gas meter unless immediately prior to the test it has been determined that the meter is in operating condition.

29.5.9.5 Checking of leakage without using a meter

This may be done by attaching to an appliance, orifice or a manometer or equivalent device and momentarily turning on the gas supply and deserving the gauging device for pressure drop with the gas supply shut-off. No discernible drop in pressure shall occur during a period of 3 min.

29.5.9.6 After piping has been checked, all gas piping shall be fully purged. Piping shall not be purged into the combustion chamber of an appliance. A suggested method for purging the gas piping to an appliance is to disconnect the pipplot piping at the outlet of the pipplot valve.

29.5.9.7 After the gas has been effectively purged, all appliances shall be purged and the pipplots lighted.

29.5.9.8 In addition to the checking of gas leakage with soap and water solution, a suitable gas detector is also recommended for use.

29.5.10 Use of liquefied petroleum gas

29.5.10.1 The cylinders used for the storage and transportation of liquefied petroleum gas (LPG) shall conform to accepted standards approved by the statutory authority.

29.5.10.2 The handling, use, storage and transportation of liquefied petroleum gas in cylinders exceeding 500 ml water capacity shall be done in accordance with good practice.

29.5.10.3 LPG cylinder installation

The following recommendations apply to installation in commercial =, industrial, educational and institutional premises.

29.5.10.3.1 General recommendations

29.5.10.3.1.1 Persons responsible for the installation of cylinders, equipment and piping should understand the characteristics of LPG and be trained in good practice of handling, installing and maintaining installations.

29.5.10.3.1.2 The jointing compound used at different joints in the system shall be decided by the Qualified Installing Agency. Hemp and similar materials shall not be used at the joint. In any joint in which the thread provides a gas-tight seal, jointing compound shall be used only on the male thread.

29.5.10.3.1.3 Fire extinguishers of dry powder type or carbon dioxide type conforming to accepted standards (9-2(4)) shall be provided in places where LPG cylinder installations are situated and shall be located near such installations. Tow buckets filled with sand and two with water shall also be installed nearby. The number, type and size of the fire extinguishers shall be as follows:
<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>For installations with LPG 40kg to 200kg</td>
<td>10kg</td>
</tr>
<tr>
<td>b)</td>
<td>For installations with LPG more than 200kg and up to 320kg</td>
<td>10kg</td>
</tr>
<tr>
<td>c)</td>
<td>For installations with LPG more than 320kg and up to 1000kg</td>
<td>10kg</td>
</tr>
</tbody>
</table>

For electrical installations, one number CO₂ fire extinguisher (4.5kg capacity) shall be provided.

29.5.10.3.1.4 Liquefied gas shall not be transferred from cylinders in which it is received to any other container.

29.5.10.3.2 Cylinder location

29.5.10.3.2.1 Stationary installations

a) Stationary installation not exceeding 40kg of LPG may be installed indoors on any floor. It is recommended to have a minimum floor area of 5m² for such an installation.

b) Stationary installations each not exceeding 40kg of LPG may be installed indoors on any floor within the same workspace provided the minimum distance between two such installations is 3m, the proportion of such installations to floor area is one installation per 5m² and the aggregate quantity of gas of all such installations does not exceed 200kg.

c) Stationary installation not exceeding 80kg of LPG may be installed indoors on any floor provided the floor area for such an installation is not less than 12m².

d) Stationary installations not exceeding 80kg of LPG may be installed indoors on any floor and within the same workspace provided the minimum distance between two such installations is 3m. The proportion of such installations to the floor area is one installation per 12m² and the aggregate quantity of gas of all such installations does not exceed 200kg.

e) Stationary installations not exceeding 320kg of LPG may be installed indoors in an enclosed clause of a building or a room reserved exclusively for this purpose and ventilated at low directly to the outside air.

f) Stationary installation above 320kg (200kg in case provided as in (e) is not possible) but not exceeding 1000kg shall be installed outdoors on ground level only. A minimum distance of 3m shall be maintained between an installation and any building, public place, roadways, and other surroundings. The installations shall be protected from excessive weathering by sun, rain, etc, and from tampering by unauthorized persons. A lean-to roof with expanded metal on angle-iron framework on the sides is considered suitable ventilation at ground level to the outside air shall be provided. The distance between any two such installations shall be 3m unless separated by a leak proof wall of fire-resistant material up to 1m above the height of the manifold valve.

g) The positions of the cylinders shall facilitate:
   1) Changing and quick removal of any cylinder in case of necessity, and
   2) Access to cylinder valve connections and regulation devices

h) Cylinders shall be installed upright with the valves uppermost.

J) Cylinders shall not be installed or used below ground level in cellars or basements

k) Cylinders containing more than 20kg of gas shall not be located on floors above ground level.

m) Cylinders shall be located on a concrete or brick floor, preferably raised in case of outdoor installations.

n) Cylinders shall not be placed close to steam pipes or any other source of heat and shall be protected from the weather and direct sun’s heat. Cylinders shall be placed at a distance of 3m away from any other source of heat which is likely to raise the temperature of cylinders above the room temperatures unless separated by metal sheet or masonry partition.

P) When cylinders are being connected or disconnected, there shall be no open flame or similar source of ignition in the vicinity; and smoking shall be prohibited.
q) Cylinders shall not be installed at a place where they are likely to cause an obstruction, to be damaged or to be exposed to conditions likely to affect their safety.

r) In order to prevent the hazardous collection of gas, cylinders shall be placed at least 1m away from culverts, depressions, or openings, leading to below ground level compartment, and drains.

s) Cylinders which have safety relief valves or similar devices incorporated in them shall be so positioned that if the relief devices operates, escaping gas is not hazardous.

29.5.10.3.2.2 Portable installations

a) The sum total capacity of the cylinders connected to each manifold shall not exceed 80kg of LPG. The total quantity of gas thus installed in a workspace shall not exceed 200kg.

b) If cylinders are mounted on trolley shall be stable. Where necessary, the cylinders shall be secured to prevent them from falling.

c) The regulatory shall be connected directly to the cylinders valve or to a manifold which shall be connected to the cylinder valves by means of rigid connections to give adequate support to the regulator. The only exception to this requirement is where cylinders are mounted on a trolley and the manifold is rigidly supported on the trolley. In such a case flexible or semi-flexible connections may be used between the manifold and the regulator.

d) At any time the total quantity of gas at portable installations shall be in proportion to the floor area as specified in 29.5.10.3.2.1(a) to 29.5.10.3.2.1(f)

e) At any time the provisions at 29.5.10.3.2.1 shall be ensured for all installations

29.5.10.3.3 Cylinder manifolds

29.5.10.3.3.1 All materials, fittings, etc, used in cylinder manifold systems shall comply with the distributing company’s stipulations.

29.5.10.3.3.2 The individual component parts of manifolds, that is, piping, fittings, pigtails, etc, which are subject to cylinder pressure shall be capable of withstand a test pressure without bursting of 2.5 N/mm² or one and a half times the maximum pressure corresponding in the maximum assessed temperature of the cylinder, whichever is more.

29.5.10.3.3.3 Where cylinder installations are made up with service and reserve batteries of cylinders, suitable change-over devices or valves shall be incorporated in the manifold header to prevent undue escape of the gas when cylinders are changed.

29.5.10.3.3.4 If pressure regulators, manifold headers, automatic change-over devices, etc, are connected to cylinders by semi-flexible connectors, they shall be rigidly supported. Copper tube pigtails are considered to be flexible or semi-flexible connectors for this purpose.

29.5.10.3.3.5 Suitable line shut-off valves shall be fitted for each appliance or burner when more than one appliance is connected to the gas supply. Both ends of the connection to portable appliances shall be securely attached by means of clips. Hose shall be of a type resistant of liquefied petroleum gas.

29.5.10.3.3.6 It is recommended that joints in manifold headers which do not have to be taken in normal use shall be welded or brazed using a material and which shall have a melting point of at least 340°C.

29.5.10.3.3.7 All joints between manifold headers and cylinders connectors shall be readily accessible.

29.5.10.3.4 Pressure Regulators

29.5.10.3.4.1 Pressure regulators and other devices used to control the gas shall comply with the distributing company’s stipulations and accepted standards (9-2(5)).

29.5.10.3.4.2 Pressure regulators fitted with a safety valve shall be either;

a) Installed in the open air, or

b) Vented to the open by means of a metal vent pipe connected to the safety valve outlet.

29.5.10.3.4.3 Care shall be taken that safety valve outlets do not become choked with dust or other foreign matter.
29.5.10.3.4.4 If the regulator is fitted with a relief valve care should taken in positioning the regulator to avoid unnecessary hazards id the relief valve functions.

29.5.10.3.4.5 Pressure regulators and other control devices shall be adequately supported.

29.5.10.3.5 Instructions to consumers

A handbook containing all instructions with regard to the following aspects shall be supplied by supplier to the consumers:

a) Operating of the whole system;

b) How to recognize gas leaks;

c) Action to be taken in case of leakage;

d) Action to be taken in case of fire; and

e) Action to be taken in case of damage to, or failure of any part of the installation.

29.5.10.3.6 For detail information regarding installation of LPG cylinders in commercial, industrial, educational and institutional premises, reference may be made to good practice (9-2(6)).

29.5.10.4 LPG Bulk storage installations

29.5.10.4.0 The following recommendations apply to LPG bulk storage installations where storage tanks over 450 liters water capacity are used at industrial, commercial and domestic consumers’ premises.

The maximum capacity of an individual tank and group of tanks at industrial, commercial and domestic premises shall be as follows:

<table>
<thead>
<tr>
<th>Premises</th>
<th>Maximum Water Capacity of an industrial tank (litres)</th>
<th>Maximum Water Capacity of group of tanks (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>130000</td>
<td>260000</td>
</tr>
<tr>
<td>Commercial</td>
<td>40000</td>
<td>80000</td>
</tr>
<tr>
<td>Domestic</td>
<td>20000</td>
<td>80000</td>
</tr>
</tbody>
</table>

29.5.10.4.1 Location and Spacing of Storage Tanks

29.5.10.4.1.1 Storage tanks shall be located outside the buildings and shall not be installed one above the other.

29.5.10.4.1.2 Each individual tank shall be located with respect to the nearest important building or group of buildings or line of adjoining property which may be built in accordance with Table 1. The distances given refer to the horizontal distance in plan between the nearest point of the storage tank and building/property line.

29.5.10.4.1.3 In heavily populated or congested areas the authority may determine the need for other reasonable protective methods to be taken, such as provisions of fire walls, etc. If fire walls are to be provided, the authority may determine the extent to which the safety distances for above ground tanks may be reduced.

29.5.10.4.1.4 No LPG tank(s) shall be located within the bunded enclosures of any petroleum installation. The minimum distance of separation between LPG storage tanks and any petroleum installation shall be as prescribed as specified in Table 1.

29.5.10.4.2 The number of storage tanks in one storage installation shall not exceed six. In case there are more than one storage installations, the safety distance between two installations shall be the same as the distance between the tanks and the property line in accordance with Table 1.

29.5.10.4.2.1 Bunding

Since LPG is heavier than air, storage tank shall not be enclosed within bund walls. The accumulation of flammable liquid under LPG.
tanks shall be prevented by suitably slopping the ground.

29.5.10.4.3 Protection

29.5.10.4.3.1 To prevent trespassing or tampering, the area which includes tanks, direct fired vapourisers, pumping equipment and loading and unloading facilities shall be enclosed by an industrial type fence at least 2 m high along the perimeter of the safety zone. Any fence shall have at least two means of exit. Gates shall open outwards and shall not be self-locking.

29.5.10.4.3.2 When damage to LPG systems from the LPG tank lorry is a possibility, precautions against such damage shall not self-locking.

29.5.10.4.3.3 Underground tanks shall be protected from above ground loading by providing a suitable curb to prevent a possible accidental damage to the tank and its fittings by LPG tank lorry.

29.5.10.4.4 Grass and Weed Removal

Road ignitable material, such as weeds, long grass or any combustible material shall be removed from an area within 3 m from the shell of any LPG tank of up to 2000 litres water capacity, and within 6 m from the shell of larger tanks. If weed killers are used, chemicals which are a potential source of fire hazards shall not be selected for this purpose.

29.5.10.4.5 Warning signs

No smoking or naked flames shall be permitted within the safety zone of the installation. Prominent notices to this effect shall be posted at access point.

29.5.10.4.6 Fire protection

The possibility of a major fire outbreak, leading to direct flame impingement of the storage tank, shall be minimized by sound engineering in plant design and layout, good operating practice, and proper education and training of personnel on both routine operations and on action to be taken in an emergency.

29.5.10.4.6.1 Water supply

Provisions shall be made for an adequate supply of water and fire protection in the storage area according to the local hoses and mobile equipment, fixed monitors or by fixed spray systems which may be automatic. Control of water flow should be possible from outside any danger area.

29.5.10.4.6.2 Fire extinguishers

At least two dry chemical powder type fire extinguishers of 10 kg capacity each, conforming to the quality requirement in accordance with the accepted standards shall be installed at points of access to the storage installations.

29.5.10.4.7 For detailed information regarding LPG bulk storage installations reference may be made to good practice.
Table 1: Minimum safety distances
(Clauses 29.5.10.4.1.2., 29.5.10.4.1.4 and 29.5.10.4.1.5)

<table>
<thead>
<tr>
<th>LPG Storage Water capacity of Individual Tank</th>
<th>Distance from building/property line</th>
<th>Distance between tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above ground m</td>
<td>Underground m</td>
</tr>
<tr>
<td>I)  Up to 2000</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>ii) Above 2000 and up to 10000</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td>iii) Above 10000 and up to 20000</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>iv) Above 20000 and up to 40000</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>v) Above 40000 and above adjacent</td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>

Note: If the aggregate water capacity of a multi-tank installations is 40000 litres or greater, the minimum safety distances shall apply to the aggregate storage capacity rather than the capacity per individual storage tank.

29.6 EXHAUST SYSTEMS
29.6.1 General
29.6.1.1 Scope
This part shall govern the design, construction and installation of mechanical exhaust systems, including exhaust systems serving and cooking appliances; hazardous exhaust systems; dust, stock and refuse conveyor systems; subslab soil exhaust systems; smoke control systems; energy recovery ventilation systems and other systems specified in Clause 29.6.2.

29.6.1.2 Independent system required.
Single or combined mechanical exhaust systems for environmental air shall be independent of all other exhaust systems. Type I exhaust systems shall be independent of all other exhaust systems except as provided in Clause 29.6.6.3.5. Single or combined Type II exhaust systems for food-processing operations shall be independent of all other exhaust systems. Kitchen exhaust systems shall be constructed in accordance with Clause 29.6.5 for domestic cooking operations and Clauses 29.6.6 through 29.6.9 for commercial cooking operations.

29.6.1.3 Exhaust discharge.
The air removed by every mechanical exhaust system shall be discharged outdoors at a point where it will not cause a public nuisance and not less than the distances specified in Clause 29.6.1.3.1. The air shall be discharged to a location from which it cannot again be readily drawn in by a ventilating system. Air shall not be exhausted into an attic, crawl space, or be directed onto walkways.

Exceptions:

1. Whole-house ventilation-type attic fans shall be permitted to discharge into the attic space of dwelling units having private attics.

2. Commercial cooking recirculating systems.

3. Where installed in accordance with the manufacturer’s instructions and where mechanical or natural ventilation is otherwise provided in accordance with Part 3, listed and labeled domestic ductless range hoods shall not be required to discharge to the outdoors.

29.6.1.3.1 Location of exhaust outlets.
The termination point of exhaust outlets and ducts discharging to the outdoors shall be located with the following minimum distances:

1. For ducts conveying explosive or flammable vapours, fumes or dusts: 914 mm (30 feet) from property lines; 3048 mm (10 feet) from operable openings into buildings; 1829 mm (6 feet) from exterior walls and roofs; 914 mm (30 feet) from combustible walls and operable openings into buildings that are in the direction of the exhaust discharge; 3048 mm (10 feet) above adjoining grade.

2. For other product-conveying outlets: 3048 mm (10 feet) from the property lines; 914 mm (3 feet) from exterior walls and roofs; 3048 mm (10 feet) from operable openings into buildings; 3048 mm (10 feet) above adjoining grade.

3. For all environmental air exhaust: 914 mm (3 feet) from property lines; 914 mm (3 feet) from operable openings into buildings for all occupancies other than Group U, and 3048 mm (10 feet) from mechanical air intakes. Such exhaust shall not be considered hazardous or noxious.

4. Exhaust outlets serving structures in flood hazard areas shall be installed at or above the elevation required by the Ghana Building Code for utilities and attendant equipment.

5. For specific systems, see the following clauses:

5.1. Kitchen hoods and other kitchen exhaust equipment, Clauses 29.6.6.3.13, 29.6.6.4 and 29.6.6.5.

5.2. Dust, stock and refuse conveying systems, Clause 29.6.11.2.

5.3. Subslab soil exhaust systems, Clause 29.6.12.4.
5.4. Smoke control systems, Clause 29.6.13.10.3.

29.6.1.3.2 Exhaust opening protection.
Exhaust openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles. Openings in screens, louvers and grilles shall be sized not less than 6.4 mm (\(\frac{1}{4}\) inch) and not larger than 12.7 mm (\(\frac{1}{2}\) inch). Openings shall be protected against local weather conditions. Louvers that protect exhaust openings in structures located in hurricane-prone regions, as defined in this Code. Outdoor openings located in exterior walls shall meet the provisions for exterior wall opening protective in accordance with the In this Code.

29.6.1.4 Pressure equalization.
Mechanical exhaust systems shall be sized to remove the quantity of air required by this part to be exhausted. The system shall operate when air is required to be exhausted. Where mechanical exhaust is required in a room or space in other than occupancies in Group R-3 and dwelling units in Group R-2, such space shall be maintained with a neutral or negative pressure. If a greater quantity of air is supplied by a mechanical ventilating supply system than is removed by a mechanical exhaust for a room, adequate means shall be provided for the natural or mechanical exhaust of the excess air supplied. If only a mechanical exhaust system is installed for a room or if a greater quantity of air is removed by a mechanical exhaust system than is supplied by a mechanical ventilating supply system for a room, adequate makeup air shall be provided to satisfy the deficiency.

29.6.2 Required Systems

29.6.2.1 General.
An exhaust system shall be provided, maintained and operated as specifically required by this clause and for all occupied areas where machines, vats, tanks, furnaces, forges, salamanders and other appliances, equipment and processes in such areas produce or throw off dust or particles sufficiently light to float in the air, or emit heat, odors, fumes, spray, gas or smoke in such quantities so as to be irritating or injurious to health or safety.

29.6.2.1.1 Exhaust location.
The inlet to an exhaust system shall be located in the area of heaviest concentration of contaminants.

29.6.2.1.2 Fuel-dispensing areas.
The bottom of an air inlet or exhaust opening in fuel-dispensing areas shall be located not more than 457 mm (18 inches) above the floor.

29.6.2.1.3 Equipment, appliance and service rooms.
Equipment, appliance and system service rooms that house sources of odors, fumes, noxious gases, smoke, steam, dust, spray or other contaminants shall be designed and constructed so as to prevent spreading of such contaminants to other occupied parts of the building.

29.6.2.1.4 Hazardous exhaust.
The mechanical exhaust of high concentrations of dust or hazardous vapours shall conform to the requirements of Clause 29.6.10.

29.6.2.2 Aircraft fueling and defueling.
Compartments housing piping, pumps, air eliminators, water separators, hose reels and similar equipment used in aircraft fueling and defueling operations shall be adequately ventilated at floor level or within the floor itself.

29.6.2.3 Battery-charging areas for powered industrial trucks and equipment.
Ventilation shall be provided in an approved manner in battery-charging areas for powered industrial trucks and equipment to prevent a dangerous accumulation of flammable gases.

29.6.2.4 Stationary storage battery systems.
Stationary storage battery systems, as required by Clause 1206.2.11.3 of the Ghana Fire Code, shall be provided with ventilation in accordance with this part and Clause 29.6.2.4.1 or 29.6.2.4.2.

The exhaust system shall be designed to provide air movement across all parts of the floor for gases having a vapour density greater than air and across all parts of the vault ceiling.
for gases having a vapour density less than air.

29.6.2.4.1 Flammability limit in rooms.
The ventilation system shall be designed to limit the maximum concentration of flammable gas to 25 percent of the lower flammability limit or, for hydrogen, limit the maximum concentration to 1.0 percent of the total volume of the room.

29.6.2.4.2 Ventilation rate in rooms.
Continuous ventilation shall be provided at a rate of not less than 1 cubic foot per minute per square foot (cfm/ft²) [0.00508 m³/(s • m²)] of floor area of the room and not less than 150 cfm (4.25 m³/min).

29.6.2.4.3 Supervision.
Mechanical ventilation systems required by Clause 502.4 shall be supervised by an approved central, proprietary or remote station service or shall initiate an audible and visual signal at a constantly attended on-site location.

29.6.2.5 Ventilation of battery systems in cabinets.
Stationary storage battery systems installed in cabinets, as regulated by the Ghana Fire Code, shall be provided with ventilation in accordance with Clause 29.6.2.4.

29.6.2.6.3 Spotting and pretreating.
Scrubbing tubs, scouring, brushing or spotting operations shall be located such that solvent vapours are captured and exhausted by the ventilating system.

29.6.2.7 Application of flammable finishes.
Mechanical exhaust as required by this clause shall be provided for operations involving the application of flammable finishes.

29.6.2.7.1 During construction.
Ventilation shall be provided for operations involving the application of materials containing flammable solvents in the course of construction, alteration or demolition of a structure.

29.6.2.7.2 Limited spraying spaces.
Positive mechanical ventilation that provides not less than six complete air changes per hour shall be installed in limited spraying spaces. Such system shall meet the requirements of the Ghana Fire Code for handling flammable vapours. Explosion venting is not required.

29.6.2.7.3 Flammable vapour areas.
Mechanical ventilation of flammable vapour areas shall be provided in accordance with Clauses 29.6.2.7.3.1 through 29.6.2.7.3.6.

29.6.2.7.3.1 Operation.
Mechanical ventilation shall be kept in operation at all times while spraying operations are being conducted and for a sufficient time thereafter to allow vapours from drying coated articles and finishing material residue to be exhausted. Spraying equipment shall be interlocked with the ventilation of the flammable vapour area such that spraying operations cannot be conducted unless the ventilation system is in operation.

29.6.2.7.3.2 Recirculation.
Air exhausted from spraying operations shall not be recirculated.

Exceptions:

1. Air exhausted from spraying operations shall be permitted to be recirculated as makeup air for unmanned spray operations provided that:

   1.1. The solid particulate has been removed.

   1.2. The vapour concentration is less than 25 percent of the lower flammable limit (LFL).

   1.3. Approved equipment is used to monitor the vapour concentration.

   1.4. An alarm is sounded and spray operations are automatically shut down if the vapour concentration...
1.5. In the event of shutdown of the vapour concentration monitor, 100 percent of the air volume specified in Clause 510 is automatically exhausted.

2. Air exhausted from spraying operations is allowed to be recirculated as makeup air to manned spraying operations where all of the conditions provided in Exception 1 are included in the installation and documents have been prepared to show that the installation does not pose a life safety hazard to personnel inside the spray booth, spraying space or spray room.

29.6.2.7.3.3 Air velocity.

The ventilation system shall be designed, installed and maintained so that the flammable contaminants are diluted in noncontaminated air to maintain concentrations in the exhaust air flow below 25 percent of the contaminant’s lower flammable limit (LFL). In addition, the spray booth shall be provided with mechanical ventilation so that the average air velocity through openings is in accordance with Clauses 29.6.2.7.3.3.1 and 29.6.2.7.3.3.2.

29.6.2.7.3.3.1 Open face or open front spray booth.

For spray application operations conducted in an open face or open front spray booth, the ventilation system shall be designed, installed and maintained so that the average air velocity into the spray booth through all openings is not less than 0.51 m/s (100 feet per minute).

Exception: For fixed or automated electrostatic spray application equipment, the average air velocity into the spray booth through all openings shall be not less than 0.25 m/s (50 feet per minute).

29.6.2.7.3.3.2 Enclosed spray booth or spray room with openings for product conveyance.

For spray application operations conducted in an enclosed spray booth or spray room with openings for product conveyance, the ventilation system shall be designed, installed and maintained so that the average air velocity into the spray booth through openings is not less than 0.51 m/s (100 feet per minute).

Exceptions:

1. For fixed or automated electrostatic spray application equipment, the average air velocity into the spray booth through all openings shall be not less than 0.25 m/s (50 feet per minute).

2. Where methods are used to reduce cross drafts that can draw vapours and overspray through openings from the spray booth or spray room, the average air velocity into the spray booth or spray room shall be that necessary to capture and confine vapours and overspray to the spray booth or spray room.

29.6.2.7.3.4 Ventilation obstruction.

Articles being sprayed shall be positioned in a manner that does not obstruct collection of overspray.

29.6.2.7.3.5 Independent ducts.

Each spray booth and spray room shall have an independent exhaust duct system discharging to the outdoors.

Exceptions:

1. Multiple spray booths having a combined frontal area of $18^2$ square feet ($1.67 \text{ m}^2$) or less are allowed to have a common exhaust where identical spray-finishing material is used in each booth. If more than one fan serves one booth, such fans shall be interconnected so that all fans operate simultaneously.
2. Where treatment of exhaust is necessary for air pollution control or energy conservation, ducts shall be allowed to be manifolded if all of the following conditions are met:

2.1. The sprayed materials used are compatible and will not react or cause ignition of the residue in the ducts.

2.2. Nitrocellulose-based finishing material shall not be used.

2.3. A filtering system shall be provided to reduce the amount of overspray carried into the duct manifold.

2.4. Automatic sprinkler protection shall be provided at the junction of each booth exhaust with the manifold, in addition to the protection required by this part.

29.6.2.7.3.6 Fan motors and belts.

Electric motors driving exhaust fans shall not be placed inside booths or ducts. Fan rotating elements shall be nonferrous or nonsparking or the casing shall consist of, or be lined with, such material. Belts shall not enter the duct or booth unless the belt and pulley within the duct are tightly enclosed.

29.6.2.7.4 Dipping operations.

Flammable vapour areas of dip tank operations shall be provided with mechanical ventilation adequate to prevent the dangerous accumulation of vapours. Required ventilation systems shall be so arranged that the failure of any ventilating fan will automatically stop the dipping conveyor system.

29.6.2.7.5 Electrostatic apparatus.

The flammable vapour area in spray-finishing operations involving electrostatic apparatus and devices shall be ventilated in accordance with Clause 29.6.2.7.3.

29.6.2.7.6 Powder coating.

Exhaust ventilation for powder-coating operations shall be sufficient to maintain the atmosphere below one-half of the minimum explosive concentration for the material being applied. Nondeposited, air-suspended powders shall be removed through exhaust ducts to the powder recovery system.

29.6.2.7.7 Floor resurfacing operations.

To prevent the accumulation of flammable vapours during floor resurfacing operations, mechanical ventilation at a minimum rate of 1 cfm/ft² [0.00508 m³/(s • m²)] of area being finished shall be provided. Such exhaust shall be by approved temporary or portable means. Vapours shall be exhausted to the outdoors.

29.6.2.8 Hazardous materials—general requirements.

Exhaust ventilation systems for structures containing hazardous materials shall be provided as required in Clauses 29.6.2.8.1 through 29.6.2.8.5.

29.6.2.8.1 Storage in excess of the maximum allowable quantities.

Indoor storage areas and storage buildings for hazardous materials in amounts exceeding the maximum allowable quantity per control area shall be provided with mechanical exhaust ventilation or natural ventilation where natural ventilation can be shown to be acceptable for the materials as stored.

Exceptions:


29.6.2.8.1.1 System requirements.

Exhaust ventilation systems shall comply with all of the following:

1. The installation shall be in accordance with this Code.

2. Mechanical ventilation shall be provided at a rate of not less than 1 cfm per square foot [0.00508 m³/(s • m²)] of floor area over the storage area.

3. The systems shall operate continuously unless alternate designs are approved.
4. A manual shutoff control shall be provided outside of the room in a position adjacent to the access door to the room or in another approved location. The switch shall be a break-glass or other approved type and shall be labeled: VENTILATION SYSTEM EMERGENCY SHUTOFF.

5. The exhaust ventilation shall be designed to consider the density of the potential fumes or vapours released. For fumes or vapours that are heavier than air, exhaust shall be taken from a point within 12 inches (305 mm) of the floor. For fumes or vapours that are lighter than air, exhaust shall be taken from a point within 12 inches (305 mm) of the highest point of the room.

6. The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapours.

7. The exhaust air shall not be recirculated to occupied areas if the materials stored are capable of emitting hazardous vapours and contaminants have not been removed. Air contaminated with explosive or flammable vapours, fumes or dusts; flammable, highly toxic or toxic gases; or radioactive materials shall not be recirculated.

**29.6.2.8.2 Gas rooms, exhausted enclosures and gas cabinets.**

The ventilation system for gas rooms, exhausted enclosures and gas cabinets for any quantity of hazardous material shall be designed to operate at a negative pressure in relation to the surrounding area. Highly toxic and toxic gases shall comply with Clauses 29.6.2.9.7.1, 29.6.2.9.7.2 and 29.6.2.9.8.4.

**29.6.2.8.3 Indoor dispensing and use.**

Indoor dispensing and use areas for hazardous materials in amounts exceeding the maximum allowable quantity per control area shall be provided with exhaust ventilation in accordance with Clause 29.6.2.8.1.

**Exception:** Ventilation is not required for dispensing and use of flammable solids other than finely divided particles.

**29.6.2.8.4 Indoor dispensing and use—pointsources.**

Where gases, liquids or solids in amounts exceeding the maximum allowable quantity per control area and having a hazard ranking of 3 or 4 in accordance with the Ghana Fire Code are dispensed or used, mechanical exhaust ventilation shall be provided to capture gases, fumes, mists or vapours at the point of generation.

**Exception:** Where it can be demonstrated that the gases, liquids or solids do not create harmful gases, fumes, mists or vapours.

**29.6.2.8.5 Closed systems.**

Where closed systems for the use of hazardous materials in amounts exceeding the maximum allowable quantity per control area are designed to be opened as part of normal operations, ventilation shall be provided in accordance with Clause 29.6.2.8.4.

**29.6.2.9 Hazardous materials—requirements for specific materials.**

Exhaust ventilation systems for specific hazardous materials shall be provided as required in Clause 29.6.2.8 and Clauses 29.6.2.9.1 through 29.6.2.9.11.

**29.6.2.9.1 Compressed gases—medical gas systems.**

Rooms for the storage of compressed medical gases in amounts exceeding the permit amounts for compressed gases in the Ghana Fire Code, and that do not have an exterior wall, shall be exhausted through a duct to the exterior of the building. Both separate airstreams shall be enclosed in a 1-hour-rated shaft enclosure from the room to the exterior. Approved mechanical ventilation shall be provided at a minimum rate of 1 cfm/ft² [0.00508 m³/(s • m²)] of the area of the room.

Gas cabinets for the storage of compressed medical gases in amounts exceeding the
permit amounts for compressed gases in the Ghana Fire Code shall be connected to an exhaust system. The average velocity of ventilation at the face of access ports or windows shall be not less than 200 feet per minute (1.02 m/s) with a minimum velocity of 150 feet per minute (0.76 m/s) at any point at the access port or window.

29.6.2.9.2 Corrosives.

Where corrosive materials in amounts exceeding the maximum allowable quantity per control area are dispensed or used, mechanical exhaust ventilation in accordance with Clause 502.8.4 shall be provided.

29.6.2.9.3 Cryogenics.

Storage areas for stationary or portable containers of cryogenic fluids in any quantity shall be ventilated in accordance with Clause 29.6.2.8. Indoor areas where cryogenic fluids in any quantity are dispensed shall be ventilated in accordance with the requirements of Clause 29.6.2.8.4 in a manner that captures any vapour at the point of generation.

Exception: Ventilation for indoor dispensing areas is not required where it can be demonstrated that the cryogenic fluids do not create harmful vapours.

29.6.2.9.4 Explosives.

Squirrel cage blowers shall not be used for exhausting hazardous fumes, vapours or gases in operating buildings and rooms for the manufacture, assembly or testing of explosives. Only nonferrous fan blades shall be used for fans located within the ductwork and through which hazardous materials are exhausted. Motors shall be located outside the duct.

29.6.2.9.5 Flammable and combustible liquids.

Exhaust ventilation systems shall be provided as required by Clauses 29.6.2.9.5.1 through 29.6.2.9.5.5 for the storage, use, dispensing, mixing and handling of flammable and combustible liquids. Unless otherwise specified, this clause shall apply to any quantity of flammable and combustible liquids.

Exception: This clause shall not apply to flammable and combustible liquids that are exempt from the Ghana Fire Code.

29.6.2.9.5.1 Vaults.

Vaults that contain tanks of Class I liquids shall be provided with continuous ventilation at a rate of not less than 1 cfm²/ft³ of floor area [0.00508 m³/(s • m²)], but not less than 150 cfm (4.25 m³/min). Failure of the exhaust airflow shall automatically shut down the dispensing system. The exhaust system shall be designed to provide air movement across all parts of the vault floor. Supply and exhaust ducts shall extend to a point not greater than 12 inches (305 mm) and not less than 3 inches (76 mm) above the floor. The exhaust system shall be installed in accordance with the provisions of Ghana Fire Code. Means shall be provided to automatically detect any flammable vapours and to automatically shut down the dispensing system upon detection of such flammable vapours in the exhaust duct at a concentration of 25 percent of the LFL.

29.6.2.9.5.2 Storage rooms and warehouses.

Liquid storage rooms and liquid storage warehouses for quantities of liquids exceeding those specified in the Ghana Fire Code shall be ventilated in accordance with Clause 29.6.2.8.1.

29.6.2.9.5.3 Cleaning machines.

Areas containing machines used for parts cleaning in accordance with the Ghana Fire Code shall be adequately ventilated to prevent accumulation of vapours.

29.6.2.9.5.4 Use, dispensing and mixing.

Continuous mechanical ventilation shall be provided for the use, dispensing and mixing of flammable and combustible liquids in open or closed systems in amounts exceeding the maximum allowable quantity per control area and for bulk transfer and process transfer operations. The ventilation rate shall be not less than 1 cfm²/ft³ [0.00508 m³/(s • m²)] of floor area over the design area. Provisions shall be made for the introduction of makeup air in a manner that will include all floor areas or pits where vapours can collect. Local or spot ventilation shall be provided where needed to prevent the accumulation of hazardous vapours.

Exception: Where natural ventilation can be shown to be effective for the materials used, dispensed or mixed.

29.6.2.9.5.5 Bulk plants or terminals.

Ventilation shall be provided for portions of properties where flammable and combustible liquids are received by tank vessels, pipelines,
tank cars or tank vehicles and are stored or blended in bulk for the purpose of distributing such liquids by tank vessels, pipelines, tank cars, tank vehicles or containers as required by Clauses 29.6.2.9.5.5.1 through 29.6.2.9.5.5.3.

29.6.2.9.5.5.1 General.

Ventilation shall be provided for rooms, buildings and enclosures in which Class I liquids are pumped, used or transferred. Design of ventilation systems shall consider the relatively high specific gravity of the vapours. Where natural ventilation is used, adequate openings in outside walls at floor level, unobstructed except by louvers or coarse screens, shall be provided. Where natural ventilation is inadequate, mechanical ventilation shall be provided.

29.6.2.9.5.5.2 Basements and pits.

Class I liquids shall not be stored or used within a building having a basement or pit into which flammable vapours can travel, unless such area is provided with ventilation designed to prevent the accumulation of flammable vapours therein.

29.6.2.9.5.5.3 Dispensing of Class I liquids.

Containers of Class I liquids shall not be drawn from or filled within buildings unless a provision is made to prevent the accumulation of flammable vapours in hazardous concentrations. Where mechanical ventilation is required, it shall be kept in operation while flammable vapours could be present.

29.6.2.9.6 Highly toxic and toxic liquids.

Ventilation exhaust shall be provided for highly toxic and toxic liquids as required by Clauses 29.6.2.9.6.1 and 29.6.2.9.6.2.

29.6.2.9.6.1 Treatment system.

This provision shall apply to indoor and outdoor storage and use of highly toxic and toxic liquids in amounts exceeding the maximum allowable quantities per control area. Exhaust scrubbers or other systems for processing vapours of highly toxic liquids shall be provided where a spill or accidental release of such liquids can be expected to release highly toxic vapours at normal temperature and pressure.

29.6.2.9.6.2 Open and closed systems.

Mechanical exhaust ventilation shall be provided for highly toxic and toxic liquids used in open systems in accordance with Clause 29.6.2.8.4. Mechanical exhaust ventilation shall be provided for highly toxic and toxic liquids used in closed systems in accordance with Clause 29.6.2.8.5.

Exception: Liquids or solids that do not generate highly toxic or toxic fumes, mists or vapours.

29.6.2.9.7 Highly toxic and toxic compressed gases—any quantity.

Ventilation exhaust shall be provided for highly toxic and toxic compressed gases in any quantity as required by Clauses 29.6.2.9.7.1 and 29.6.2.9.7.2.

29.6.2.9.7.1 Gas cabinets.

Gas cabinets containing highly toxic or toxic compressed gases in any quantity shall comply with Clause 29.6.2.8.2 and the following requirements:

1. The average ventilation velocity at the face of gas cabinet access ports or windows shall be not less than 1.02 m/s (200 feet per minute) with a minimum velocity of 0.76 m/s (150 feet per minute) at any point at the access port or window.

2. Gas cabinets shall be connected to an exhaust system.

3. Gas cabinets shall not be used as the sole means of exhaust for any room or area.

29.6.2.9.7.2 Exhausted enclosures.

Exhausted enclosures containing highly toxic or toxic compressed gases in any quantity shall comply with Clause 29.6.2.8.2 and the following requirements:

1. The average ventilation velocity at the face of the enclosure shall be not less than 1.02 m/s (200 feet per minute) with a minimum velocity of 0.76 m/s (150 feet per minute).

2. Exhausted enclosures shall be connected to an exhaust system.

3. Exhausted enclosures shall not be used as the sole means of exhaust for any room or area.
29.6.2.9.8 Highly toxic and toxic compressed gases—quantities exceeding the maximum allowable quantity per control area.
Ventilation exhaust shall be provided for highly toxic and toxic compressed gases in amounts exceeding the maximum allowable quantities per control area as required by Clauses 29.6.2.9.8.1 through 29.6.2.9.8.6.

29.6.2.9.8.1 Ventilated areas.
The room or area in which indoor gas cabinets or exhausted enclosures are located shall be provided with exhaust ventilation. Gas cabinets or exhausted enclosures shall not be used as the sole means of exhaust for any room or area.

29.6.2.9.8.2 Local exhaust for portable tanks.
A means of local exhaust shall be provided to capture leakage from indoor and outdoor portable tanks. The local exhaust shall consist of portable ducts or collection systems designed to be applied to the site of a leak in a valve or fitting on the tank. The local exhaust system shall be located in a gas room. Exhaust shall be directed to a treatment system where required by the Ghana Fire Code.

29.6.2.9.8.3 Piping and controls—stationary tanks.
Filling or dispensing connections on indoor stationary tanks shall be provided with a means of local exhaust. Such exhaust shall be designed to capture fumes and vapours. The exhaust shall be directed to a treatment system where required by the Ghana Fire Code.

29.6.2.9.8.4 Gas rooms.
The ventilation system for gas rooms shall be designed to operate at a negative pressure in relation to the surrounding area. The exhaust ventilation from gas rooms shall be directed to an exhaust system.

29.6.2.9.8.5 Treatment system.
The exhaust ventilation from gas cabinets, exhausted enclosures and gas rooms, and local exhaust systems required in Clauses 29.6.2.9.8.2 and 29.6.2.9.8.3 shall be directed to a treatment system where required by the Ghana Fire Code.

29.6.2.9.8.6 Process equipment.
Effluent from indoor and outdoor process equipment containing highly toxic or toxic compressed gases which could be discharged to the atmosphere shall be processed through an exhaust scrubber or other processing system. Such systems shall be in accordance with the Ghana Fire Code.

29.6.2.9.9 Ozone gas generators.
Ozon cabinets and ozone gas-generator rooms for systems having a maximum ozone-generating capacity of \( \frac{1}{2} \) pound (0.23 kg) or more over a 24-hour period shall be mechanically ventilated at a rate of not less than six air changes per hour. For cabinets, the average velocity of ventilation at makeup air openings with cabinet doors closed shall be not less than 200 feet per minute (1.02 m/s).

29.6.2.9.10 LP-gas distribution facilities.
LP-gas distribution facilities shall be ventilated in accordance with Ghana Fire Code.

29.6.2.9.10.1 Portable container use.
Above-grade underfloor spaces or basements in which portable LP-gas containers are used or are stored awaiting use or resale shall be provided with an approved means of ventilation.

Exception: Department of Transportation (DOT) specification cylinders with a maximum water capacity of 2.7 pounds (1.2 kg) for use in completely self-contained hand torches and similar applications. The quantity of LP-gas shall not exceed 20 pounds (9 kg).

29.6.2.9.11 Silane gas.
Exhausted enclosures and gas cabinets for the indoor storage of silane gas in amounts exceeding the maximum allowable quantities per control area shall comply with Part 64 of the Ghana Fire Code.

29.6.2.10 Hazardous production materials (HPM).
Exhaust ventilation systems and materials for ducts utilized for the exhaust of HPM shall comply with this clause, other applicable provisions of this Code, the Ghana Building Code and the Ghana Fire Code.
29.6.2.10.1 Where required.
Exhaust ventilation systems shall be provided in the following locations in accordance with the requirements of this clause and the Ghana Building Code.

1. Fabrication areas: Exhaust ventilation for fabrication areas shall comply with the Ghana Building Code. Additional manual control switches shall be provided where required by the Code official.

2. Workstations: A ventilation system shall be provided to capture and exhaust gases, fumes and vapours at workstations.

3. Liquid storage rooms: Exhaust ventilation for liquid storage rooms shall comply with Clause 29.6.2.8.1.1 and the Ghana Building Code.

4. HPM rooms: Exhaust ventilation for HPM rooms shall comply with Clause 29.6.2.8.1.1 and the Ghana Building Code.

5. Gas cabinets: Exhaust ventilation for gas cabinets shall comply with Clause 29.6.2.8.2. The gas cabinet ventilation system is allowed to connect to a workstation ventilation system. Exhaust ventilation for gas cabinets containing highly toxic or toxic gases shall also comply with Clauses 29.6.2.9.7 and 29.6.2.9.8.

6. Exhausted enclosures: Exhaust ventilation for exhausted enclosures shall comply with Clause 29.6.2.8.2. Exhaust ventilation for exhausted enclosures containing highly toxic or toxic gases shall also comply with Clauses 29.6.2.9.7 and 29.6.2.9.8.

7. Gas rooms: Exhaust ventilation for gas rooms shall comply with Clause 29.6.2.8.2. Exhaust ventilation for gas rooms containing highly toxic or toxic gases shall also comply with Clauses 29.6.2.9.7 and 29.6.2.9.8.

8. Cabinets containing pyrophoric liquids or Class 3 water-reactive liquids: Exhaust ventilation for cabinets in fabrication areas containing pyrophoric liquids shall be as required in Clause 28.5.2.3.4 of the Ghana Fire Code.

29.6.2.10.2 Penetrations.
Exhaust ducts penetrating fire barriers constructed in accordance with this Code or horizontal assemblies constructed in accordance with this Code shall be contained in a shaft of equivalent fire-resistance-rated construction. Exhaust ducts shall not penetrate fire walls. Fire dampers shall not be installed in exhaust ducts.

29.6.2.10.3 Treatment systems.
Treatment systems for highly toxic and toxic gases shall comply with the Ghana Fire Code.

29.6.2.11 Motion picture projectors.
Motion picture projectors shall be exhausted in accordance with Clause 29.6.2.11.1 or 29.6.2.11.2.

29.6.2.11.1 Projectors with an exhaust discharge.
Projectors equipped with an exhaust discharge shall be directly connected to a mechanical exhaust system. The exhaust system shall operate at an exhaust rate as indicated by the manufacturer’s installation instructions.

29.6.2.11.2 Projectors without exhaust connection.
Projectors without an exhaust connection shall have contaminants exhausted through a mechanical exhaust system. The exhaust rate for electric arc projectors shall be not less than 200 cubic feet per minute (cfm) (0.09 m$^3$/s) per lamp. The exhaust rate for xenon projectors shall be not less than 300 cfm (0.14 m$^3$/s) per lamp. Xenon projector exhaust shall be at a rate such that the exterior temperature of the lamp housing does not exceed 130°F (54°C). The lamp and projection room exhaust systems, whether combined or independent, shall not be interconnected with any other exhaust or return system within the building.

29.6.2.12 Organic coating processes.
Enclosed structures involving organic coating processes in which Class I liquids are
processed or handled shall be ventilated at a rate of not less than 1 cfm/ft$^2$ [0.00508 m$^3$/s • m$^2$] of solid floor area. Ventilation shall be accomplished by exhaust fans that intake at floor levels and discharge to a safe location outside the structure. Noncontaminated intake air shall be introduced in such a manner that all portions of solid floor areas are provided with continuous uniformly distributed air movement.

29.6.2.13 Public garages.
Mechanical exhaust systems for public garages, as required in Part 4, shall operate continuously or in accordance with this Code.

29.6.2.14 Motor vehicle operation.
In areas where motor vehicles operate, mechanical ventilation shall be provided in accordance with Clause 4.3. Additionally, areas in which stationary motor vehicles are operated shall be provided with a source capture system that connects directly to the motor vehicle exhaust systems. Such system shall be engineered by a registered design professional or shall be factory-built equipment designed and sized for the purpose.

Exceptions:

1. This clause shall not apply where the motor vehicles being operated or repaired are electrically powered.
2. This clause shall not apply to one and two-family dwellings.
3. This clause shall not apply to motor vehicle service areas where engines are operated inside the building only for the duration necessary to move the motor vehicles in and out of the building.

29.6.2.16 Repair garages for vehicles fueled by lighter-than-air fuels.
Repair garages used for the conversion and repair of vehicles that use compressed natural gas, liquefied natural gas, hydrogen or other lighter-than-air motor fuels shall be provided with an approved mechanical exhaust ventilation system. The mechanical exhaust ventilation system shall be in accordance with Clause 29.6.2.16.1 or 29.6.2.16.2 as applicable.

Exceptions:

1. Repair garages where work is not performed on the fuel system and is limited to exchange of parts and maintenance not requiring open flame or welding on the compressed natural gas, liquefied natural gas, hydrogen or other lighter-than-air-fueled motor vehicle.
2. Repair garages for hydrogen-fueled vehicles where work is not performed on the hydrogen storage tank and is limited to the exchange of parts and maintenance not requiring open flame or welding on the hydrogen-fueled vehicle. During the work, the entire hydrogen fuel system shall contain a quantity of hydrogen that is less than 200 cubic feet (5.6 m$^3$).

29.6.2.16.1 Repair garages for hydrogen-fueled vehicles.
Repair garages used for the repair of hydrogen-fueled vehicles shall be provided with an approved exhaust ventilation system in accordance with this Code.

29.6.2.16.2 Exhaust ventilation system.
Repair garages used for the repair of compressed natural gas, liquefied natural gas or other lighter-than-air motor fuel, other than hydrogen, shall be provided with an approved mechanical exhaust ventilation system. The mechanical exhaust ventilation system shall be in accordance with this Code and Clauses 29.6.2.16.2.1 and 29.6.2.16.2.2.

Exception: Where approved, natural ventilation shall be an alternative to mechanical exhaust ventilation.
29.6.2.16.2.1 Design.
For indoor locations, air supply inlets and exhaust outlets for mechanical ventilation shall be arranged to provide uniformly distributed air movement with inlets uniformly arranged on walls near floor level and outlets located at the high point of the room in walls or the roof. Failure of the exhaust ventilation system shall cause the fueling system to shut down. The exhaust ventilation rate shall be not less than 1 cubic foot per minute (0.03 m³/min) per 12 cubic feet (0.34 m³) of room volume.

29.6.2.16.2.2 Operation.
The mechanical exhaust ventilation system shall operate continuously.

Exceptions:
1. Mechanical exhaust ventilation systems that are interlocked with a gas detection system designed in accordance with the Ghana Fire Code.
2. Mechanical exhaust ventilation systems in garages that are used only for the repair of vehicles fueled by liquid fuels or odorized gases, such as compressed natural gas, where the exhaust ventilation system is electrically interlocked with the lighting circuit.

29.6.2.17 Tire rebuilding or recapping.
Each room where rubber cement is used or mixed, or where flammable or combustible solvents are applied, shall be ventilated in accordance with the applicable provisions of NFPA 91.

29.6.2.17.1 Buffing machines.
Each buffing machine shall be connected to a dust-collecting system that prevents the accumulation of the dust produced by the buffing process.

29.6.2.18 Specific rooms.
Specific rooms, including bathrooms, locker rooms, smoking lounges and toilet rooms, shall be exhausted in accordance with the ventilation requirements of this Code.

29.6.2.19 Indoor firing ranges.
Ventilation shall be provided in an approved manner in areas utilized as indoor firing ranges. Ventilation shall be designed to protect employees and the public in accordance with this Code.

29.6.2.20 Manicure and pedicure stations.
Manicure and pedicure stations shall be provided with an exhaust system in accordance with Table 303.3.1.1, Note h. Manicure tables and pedicure stations not provided with factory-installed exhaust inlets shall be provided with exhaust inlets located not more than 12 inches (305 mm) horizontally and vertically from the point of chemical application.

29.6.3 Motors and Fans
29.6.3.1 General.
Motors and fans shall be sized to provide the required air movement. Motors in areas that contain flammable vapours or dusts shall be of a type approved for such environments. A manually operated remote control installed at an approved location shall be provided to shut off fans or blowers in flammable vapour or dust systems. Electrical equipment and appliances used in operations that generate explosive or flammable vapours, fumes or dusts shall be electrically interlocked with the ventilation system so that the equipment and appliances cannot be operated unless the ventilation fans are in operation. Motors for fans used to convey flammable vapours or dusts shall be located outside the duct or shall be protected with approved shields and dustproofing. Motors and fans shall be provided with a means of access for servicing and maintenance.

29.6.3.2 Fans.
Parts of fans in contact with explosive or flammable vapours, fumes or dusts shall be of nonferrous or nonsparking materials, or their casing shall be lined or constructed of such material. Where the size and hardness of materials passing through a fan are capable of producing a spark, both the fan and the casing shall be of nonsparking materials. Where fans are required to be spark resistant, their bearings shall not be within the airstream, and all parts of the fan shall be grounded. Fans in systems-handling materials that are capable of clogging the blades, and fans in buffing or woodworking exhaust systems, shall be of the radial-blade or tube-axial type.

29.6.3.3 Equipment and appliance identification plate.
Equipment and appliances used to exhaust explosive or flammable vapours, fumes or dusts shall bear an identification plate stating
the ventilation rate for which the system was designed.

29.6.3.4 Corrosion-resistant fans.
Fans located in systems conveying corrosives shall be of materials that are resistant to the corrosive or shall be coated with corrosion-resistant materials.

29.6.4 DOMESTIC COOKING EXHAUST EQUIPMENT

29.6.4.1 General.
Domestic cooking exhaust equipment shall comply with the requirements of this clause.

29.6.4.2 Domestic cooking exhaust.
Where domestic cooking exhaust equipment is provided, it shall comply with the following as applicable:

1. The fan for overhead range hoods and downdraft exhaust equipment not integral with the cooking appliance shall be listed and labeled in accordance with this Code.

2. Overhead range hoods and downdraft exhaust equipment with integral fans shall comply with this Code.

3. Domestic cooking appliances with integral downdraft exhaust equipment shall be listed and labeled in accordance with this Code.

4. Microwave ovens with integral exhaust for installation over the cooking surface shall be listed and labeled in accordance with this Code.

29.6.4.3 Exhaust ducts.
Domestic cooking exhaust equipment shall discharge to the outdoors through sheet metal ducts constructed of galvanized steel, stainless steel, aluminum or copper. Such ducts shall have smooth inner walls, be air tight, shall be equipped with a backdraft damper, and shall be independent of all other exhaust systems. Installations in Group I-1 and I-2 occupancies shall be in accordance with the Ghana Building Code and the Ghana Fire Code.

Exceptions:

1. In other than Groups I-1 and I-2, where installed in accordance with the manufacturer’s instructions and where mechanical or natural ventilation is otherwise provided in accordance with Part 3, listed and labeled ductless range hoods shall not be required to discharge to the outdoors.

2. Ducts for domestic kitchen cooking appliances equipped with downdraft exhaust systems shall be permitted to be constructed of Schedule 40 PVC pipe and fittings provided that the installation complies with all of the following:

   2.1. The duct shall be installed under a concrete slab poured on grade.

   2.2. The underfloor trench in which the duct is installed shall be completely backfilled with sand or gravel.

   2.3. The PVC duct shall extend not more than 25 mm (1 inch) above the indoor concrete floor surface.

   2.4. The PVC duct shall extend not more than 25 mm (1 inch) above grade outside of the building.

   2.5. The PVC ducts shall be solvent cemented.

29.6.4.4 Makeup air required.
Exhaust hood systems capable of exhausting in excess of 400 cfm (0.19 m³/s) shall be provided with makeup air at a rate approximately equal to the exhaust air rate. Such makeup air systems shall be equipped with a means of closure and shall be automatically controlled to start and operate simultaneously with the exhaust system.

29.6.4.5 Common exhaust systems for domestic kitchens located in multistorey structures.
Where a common multistorey duct system is designed and installed to convey exhaust from multiple domestic kitchen exhaust systems, the construction of the system shall be in accordance with all of the following:
1. The shaft in which the duct is installed shall be constructed and fire-resistance rated as required by the Ghana Building Code.

2. Dampers shall be prohibited in the exhaust duct, except as specified in Clause 505.3. Penetrations of the shaft and ductwork shall be protected in accordance with Clause 607.5.5, Exception 2.

3. Rigid metal ductwork shall be installed within the shaft to convey the exhaust. The ductwork shall be constructed of sheet steel having a minimum thickness of 0.0187 inch (0.4712 mm) (No. 26 gage) and in accordance with this Code.

4. The ductwork within the shaft shall be designed and installed without offsets.

5. The exhaust fan motor design shall be in accordance with this Code.

6. The exhaust fan motor shall be located outside of the airstream.

7. The exhaust fan shall run continuously, and shall be connected to a standby power source.

8. Exhaust fan operation shall be monitored in an approved location and shall initiate an audible or visual signal when the fan is not in operation.

9. Where the exhaust rate for an individual kitchen exceeds 400 cfm (0.19 m³/s) makeup air shall be provided in accordance with this Code.

10. A cleanout opening shall be located at the base of the shaft to provide access to the duct to allow for cleanout and inspection. The finished openings shall be not less than 12 inches by 12 inches (305 mm by 305 mm).

11. Screens shall not be installed at the termination.

12. The common multistorey duct system shall serve only kitchen exhaust and shall be independent of other exhaust systems.

29.6.4.6 Other than Group R.
In other than Group R occupancies, where domestic cooktops, ranges, and open-top broilers are used for domestic purposes, domestic cooking exhaust systems shall be provided.

29.6.5 Commercial Kitchen Hood Ventilation System Ducts and Exhaust Equipment

29.6.5.1 General.
Commercial kitchen hood ventilation ducts and exhaust equipment shall comply with the requirements of this clause. Commercial kitchen grease ducts shall be designed for the type of cooking appliance and hood served.

29.6.5.2 Corrosion protection.
Ducts exposed to the outside atmosphere or subject to a corrosive environment shall be protected against corrosion in an approved manner.

29.6.5.3 Ducts serving Type I hoods.
Type I exhaust ducts shall be independent of all other exhaust systems except as provided in Clause 506.3.5. Commercial kitchen duct systems serving Type I hoods shall be designed, constructed and installed in accordance with Clauses 29.6.5.3.1 through 29.6.5.3.13.3.

29.6.5.3.1 Duct materials.
Ducts serving Type I hoods shall be constructed of materials in accordance with Clauses 29.6.5.3.1.1 and 29.6.5.3.1.2.

29.6.5.3.1.1 Grease duct materials.
Grease ducts serving Type I hoods shall be constructed of steel having a minimum thickness of 1.463 mm (0.0575 inch) (No. 16 gage) or stainless steel not less than 1.14 mm (0.0450 inch) (No. 18 gage) in thickness.

Exception: Factory-built commercial kitchen grease ducts listed and labeled in accordance with this Code.

29.6.5.3.2 Joints, seams and penetrations of grease ducts.
Joints, seams and penetrations of grease ducts shall be made with a continuous liquid-tight weld or braze made on the external surface of the duct system.

Exceptions:
1. Penetrations shall not be required to be welded or brazed where sealed by devices that are listed for the application.

2. Internal welding or brazing shall not be prohibited provided that the joint is formed or ground smooth and is provided with ready access for inspection.

3. Factory-built commercial kitchen grease ducts listed and labeled in accordance with this Code and installed in accordance with this Code.

29.6.5.3.2.1 Duct joint types.

Duct joints shall be butt joints, welded flange joints with a maximum flange depth of 12.7 mm (1/2 inch) or overlapping duct joints of either the telescoping or bell type. Overlapping joints shall be installed to prevent ledges and obstructions from collecting grease or interfering with gravity drainage to the intended collection point. The difference between the inside cross-clauseal dimensions of overlapping clauses of duct shall not exceed 6.4 mm (1/4 inch). The length of overlap for overlapping duct joints shall not exceed 2 inches (51 mm).

29.6.5.3.2.2 Duct-to-hood joints.

Duct-to-hood joints shall be made with continuous internal or external liquid-tight welded or brazed joints. Such joints shall be smooth, accessible for inspection, and without grease traps.

Exceptions: This clause shall not apply to:

1. A vertical duct-to-hood collar connection made in the top plane of the hood in accordance with all of the following:

   1.1. The hood duct opening shall have a 25 mm (1-inch-deep), full perimeter, welded flange turned down into the hood interior at an angle of 90 degrees (1.57 rad) from the plane of the opening.

   1.2. The duct shall have a 25 mm - deep (1-inch) flange made by a 25 mm by 25 mm (1-inch by 1-inch) angle iron welded to the full perimeter of the duct not less than 1 inch (25 mm) above the bottom end of the duct.

   1.3. A gasket rated for use at not less than 1500ºF (816ºC) is installed between the duct flange and the top of the hood.

   1.4. The duct-to-hood joint shall be secured by stud bolts not less than 6.4 mm (1/4 inch) in diameter welded to the hood with a spacing not greater than 4 inches (102 mm) on center for the full perimeter of the opening. The bolts and nuts shall be secured with lockwashers.

2. Listed and labeled duct-to-hood collar connections installed in accordance with this Code.

29.6.5.3.2.3 Duct-to-exhaust fan connections.

Duct-to-exhaust fan connections shall be flanged and gasketed at the base of the fan for vertical discharge fans; shall be flanged.
gasketed and bolted to the inlet of the fan for side-inlet utility fans; and shall be flanged, gasketed and bolted to the inlet and outlet of the fan for in-line fans. Gasket and sealing materials shall be rated for continuous duty at a temperature of not less than 1500°F (816°C).

**29.6.5.3.2.4 Vibration isolation.**

A vibration isolation connector for connecting a duct to a fan shall consist of noncombustible packing in a metal sleeve joint of approved design or shall be a coated-fabric flexible duct connector listed and labeled for the application. Vibration isolation connectors shall be installed only at the connection of a duct to a fan inlet or outlet.

**29.6.5.3.2.5 Grease duct test.**

Prior to the use or concealment of any portion of a grease duct system, a leakage test shall be performed. Ducts shall be considered to be concealed where installed in shafts or covered by coatings or wraps that prevent the ductwork from being visually inspected on all sides. The permit holder shall be responsible to provide the necessary equipment and perform the grease duct leakage test. A light test shall be performed to determine that all welded and brazed joints are liquid tight.

A light test shall be performed by passing a lamp having a power rating of not less than 100 watts through the entire clause of ductwork to be tested. The lamp shall be open so as to emit light equally in all directions perpendicular to the duct walls. A test shall be performed for the entire duct system, including the hood-to-duct connection. The duct work shall be permitted to be tested in clauses, provided that every joint is tested. For listed factory-built grease ducts, this test shall be limited to duct joints assembled in the field and shall exclude factory welds.

**29.6.5.3.3 Grease duct supports.**

Grease duct bracing and supports shall be of noncombustible material securely attached to the structure and designed to carry gravity and seismic loads within the stress limitations of the Ghana Building Code. Bolts, screws, rivets and other mechanical fasteners shall not penetrate duct walls.

**29.6.5.3.4 Air velocity.**

Grease duct systems serving a Type I hood shall be designed and installed to provide an air velocity within the duct system of not less than 500 feet per minute (2.5 m/s).

**Exception:** The velocity limitations shall not apply within duct transitions utilized to connect ducts to differently sized or shaped openings in hoods and fans, provided that such transitions do not exceed 3 feet (914 mm) in length and are designed to prevent the trapping of grease.

**29.6.5.3.5 Separation of grease duct system.**

A separate grease duct system shall be provided for each Type I hood. A separate grease duct system is not required where all of the following conditions are met:

1. All interconnected hoods are located within the same storey.

2. All interconnected hoods are located within the same room or in adjoining rooms.

3. Interconnecting ducts do not penetrate assemblies required to be fire-resistance rated.

4. The grease duct system does not serve solid-fuel-fired appliances.

**29.6.5.3.6 Grease duct clearances.**

Where enclosures are not required, grease duct systems and exhaust equipment serving a Type I hood shall have a clearance to combustible construction of not less than 18 inches (457 mm), and shall have a clearance to noncombustible construction and gypsum wallboard attached to noncombustible structures of not less than 3 inches (76 mm).

**Exceptions:**

1. Factory-built commercial kitchen grease ducts listed and labeled in accordance with this Code.

2. Listed and labeled exhaust equipment installed in accordance with this Code.

3. Where commercial kitchen grease ducts are continuously covered on all sides with a listed and labeled field-applied grease duct enclosure material, system, product or method of construction specifically evaluated for such purpose in accordance with
ASTM E2336, the required clearance shall be in accordance with the listing of such material, system, product or method.

29.6.5.3.7 Prevention of grease accumulation in grease ducts.
Duct systems serving a Type I hood shall be constructed and installed so that grease cannot collect in any portion thereof, and the system shall slope not less than one-fourth unit vertical in 12 units horizontal (2-percent slope) toward the hood or toward a grease reservoir designed and installed in accordance with this Code. Where horizontal ducts exceed 22 860 mm (75 feet) in length, the slope shall be not less than one unit vertical in 12 units horizontal (8.3-percent slope).

506.3.7.1 Grease duct reservoirs.
Grease duct reservoirs shall:

1. Be constructed as required for the grease duct they serve.
2. Be located on the bottom of the horizontal duct or the bottommost clause of the duct riser.
3. Extend across the full width of the duct and have a length of not less than 305 mm (12 inches).
4. Have a depth of not less than 25 mm (1 inch).
5. Have a bottom that slopes to a drain.
6. Be provided with a cleanout opening constructed in accordance with Clause 29.5.6.3.8 and installed to provide direct access to the reservoir. The cleanout opening shall be located on a side or on top of the duct so as to permit cleaning of the reservoir.
7. Be installed in accordance with the manufacturer’s instructions where manufactured devices are utilized.

29.6.5.3.8 Grease duct cleanouts and openings.
Grease duct cleanouts and openings shall comply with all of the following:

1. Grease ducts shall not have openings except where required for the operation and maintenance of the system.
2. Clauses of grease ducts that are inaccessible from the hood or discharge openings shall be provided with cleanout openings spaced not more than 20 feet (6096 mm) apart and not more than 10 feet (3048 mm) from changes in direction greater than 45 degrees (0.79 rad).
3. Cleanouts and openings shall be equipped with tight-fitting doors constructed of steel having a thickness not less than that required for the duct.
4. Cleanout doors shall be installed liquid tight.
5. Door assemblies including any frames and gaskets shall be approved for the application and shall not have fasteners that penetrate the duct.
6. Gasket and sealing materials shall be rated for not less than 1500ºF (816ºC).
7. Listed door assemblies shall be installed in accordance with the manufacturer’s instructions.

29.6.5.3.8.1 Personnel entry.
Where ductwork is large enough to allow entry of personnel, not less than one approved or listed opening having dimensions not less than 559 mm by 508 mm (22 inches by 20 inches) shall be provided in the horizontal clauses, and in the top of vertical risers. Where such entry is provided, the duct and its supports shall be capable of supporting the additional load, and the cleanouts specified in Clause 29.6.5.3.8 are not required.

29.6.5.3.8.2 Cleanouts serving in-line fans.
A cleanout shall be provided for both the inlet side and outlet side of an in-line fan except
where a duct does not connect to the fan. Such cleanouts shall be located within 914 mm (3 feet) of the fan duct connections.

29.6.5.3.9 Grease duct horizontal cleanouts.
Cleanouts serving horizontal clauses of grease ducts shall:

1. Be spaced not more than 6096 mm (20 feet) apart.

2. Be located not more than 3048 mm (10 feet) from changes in direction that are greater than 45 degrees (0.79 rad).

3. Be located on the bottom only where other locations are not available and shall be provided with internal damming of the opening such that grease will flow past the opening without pooling. Bottom cleanouts and openings shall be approved for the application and installed liquid-tight.

4. Not be closer than 25 mm (1 inch) from the edges of the duct.

5. Have opening dimensions of not less than 305 mm by 305 mm (12 inches by 12 inches). Where such dimensions preclude installation, the opening shall be not less than 12 inches (305 mm) on one side and shall be large enough to provide access for cleaning and maintenance.

6. Shall be located at grease reservoirs.

29.6.5.3.10 Underground grease duct installation.
Underground grease duct installations shall comply with all of the following:

1. Underground grease ducts shall be constructed of steel having a minimum thickness of 1.463 mm (0.0575 inch) (No. 16 gage) and shall be coated to provide protection from corrosion or shall be constructed of stainless steel having a minimum thickness of 1.140 mm (0.0450 inch) (No. 18 gage).

2. The underground duct system shall be tested and approved in accordance with Clause 29.6.5.3.2.5 prior to coating or placement in the ground.

3. The underground duct system shall be completely encased in concrete with a minimum thickness of 102 mm (4 inches).

4. Ducts shall slope toward grease reservoirs.

5. A grease reservoir with a cleanout to allow cleaning of the reservoir shall be provided at the base of each vertical duct riser.

6. Cleanouts shall be provided with access to permit cleaning and inspection of the duct in accordance with Clause 29.6.5.3.

7. Cleanouts in horizontal ducts shall be installed on the topside of the duct.

8. Cleanout locations shall be legibly identified at the point of access from the interior space.

29.6.5.3.11 Grease duct enclosures.
A commercial kitchen grease duct serving a Type I hood that penetrates a ceiling, wall, floor or any concealed space shall be enclosed from the point of penetration to the outlet terminal. In-line exhaust fans not located outdoors shall be enclosed as required for grease ducts. A duct shall penetrate exterior walls only at locations where unprotected openings are permitted by the Ghana Building Code. The duct enclosure shall serve a single grease duct and shall not contain other ducts, piping or wiring systems. Duct enclosures shall be a shaft enclosure in accordance with Clause 29.6.5.3.11.1, a field-applied enclosure assembly in accordance with Clause 29.6.5.3.11.2 or a factory-built enclosure assembly in accordance with Clause 29.6.5.3.11.3. Duct enclosures shall have a fire-resistance rating of not less than that of the assembly penetrated and not less than 1 hour. Fire dampers and smoke dampers shall not be installed in grease ducts.

Exception: A duct enclosure shall not be required for a grease duct that penetrates only
29.6.5.3.11.1 Shaft enclosure.

Greas e ducts constructed in accordance with Clause 29.6.5.3.1 shall be permitted to be enclosed in accordance with the Ghana Building Code requirements for shaft construction. Such grease duct systems and exhaust equipment shall have a clearance to combustible construction of not less than 457 mm (18 inches), and shall have a clearance to noncombustible construction and gypsum wallboard attached to noncombustible structures of not less than 76 mm (6 inches). Duct enclosures shall be sealed around the duct at the point of penetration and vented to the outside of the building through the use of weather-protected openings.

29.6.5.3.11.2 Field-applied grease duct enclosure.

Greas e ducts constructed in accordance with Clause 29.6.5.3.1 shall be enclosed by a listed and labeled field-applied grease duct enclosure material, systems, product, or method of construction specifically evaluated for such purpose in accordance with ASTM E814. The surface of the duct shall be continuously covered on all sides from the point at which the duct originates to the outlet terminal. Duct penetrations shall be protected with a through-penetration firestop system tested and listed in accordance with ASTM E814 or UL 1479 and having a “F” and “T” rating equal to the fire-resistive rating of the assembly being penetrated. The grease duct enclosure and firestop system shall be installed in accordance with the listing and the manufacturer’s instructions. Partial application of a field applied grease duct enclosure shall not be installed for the sole purpose of reducing clearances to combustibles at isolated clauses of grease duct. Exposed duct-wrap systems shall be protected where subject to physical damage.

29.6.5.3.11.3 Factory-built grease duct enclosure assemblies.

Factory-built grease ducts incorporating integral enclosure materials shall be listed and labeled for use as grease duct enclosure assemblies specifically evaluated for such purpose in accordance with this Code. Duct penetrations shall be protected with a through-penetration firestop system tested and listed in accordance with ASTM E814 and having an “F” and “T” rating equal to the fire-resistive rating of the assembly being penetrated. The grease duct enclosure assembly and firestop system shall be installed in accordance with the listing and the manufacturer’s instructions.

29.6.5.3.12 Grease duct fire-resistive access opening.

Where cleanout openings are located in ducts within a fire-resistive-rated enclosure, access openings shall be provided in the enclosure at each cleanout point. Access openings shall be equipped with tight-fitting sliding or hinged doors that are equal in fire-resistive protection to that of the shaft or enclosure. An approved sign shall be placed on access opening panels with wording as follows: “ACCESS PANEL. DO NOT OBSTRUCT.”

29.6.5.3.13 Exhaust outlets serving Type I hoods.

Exhaust outlets for grease ducts serving Type I hoods shall conform to the requirements of Clauses 29.6.5.3.13.1 through 29.5.6.3.13.3.

29.6.5.3.13.1 Termination above the roof.

Exhaust outlets that terminate above the roof shall have the discharge opening located not less than 1016 mm (40 inches) above the roof surface.

29.6.5.3.13.2 Termination through an exterior wall.

Exhaust outlets shall be permitted to terminate through exterior walls where the smoke, grease, gases, vapours and odors in the discharge from such terminations do not create a public nuisance or a fire hazard. Such terminations shall not be located where protected openings are required by the Ghana Building Code. Such terminations shall be located in accordance with Clause 29.6.5.3.13.3 and shall not be located within 914 mm (3 feet) of any opening in the exterior wall.

29.6.5.3.13.3 Termination location.

Exhaust outlets shall be located not less than 3048 mm (10 feet) horizontally from parts of the same or contiguous buildings, adjacent buildings and adjacent property lines and shall be located not less than 3048 mm (10 feet) above the adjoining grade level. Exhaust outlets shall be located not less than 10 feet (3048 mm) horizontally from or not less than
914 mm (3 feet) above air intake openings into any building.

**Exception:** Exhaust outlets shall terminate not less than 1524 mm (5 feet) horizontally from parts of the same or contiguous building, an adjacent building, adjacent property line and air intake openings into a building where air from the exhaust outlet discharges away from such locations.

29.6.5.4 Ducts serving Type II hoods. Commercial kitchen exhaust systems serving Type II hoods shall comply with Clauses 29.6.5.4.1 and 29.6.5.4.2.

29.6.5.4.1 Ducts. Ducts and plenums serving Type II hoods shall be constructed of rigid metallic materials. Ducts subject to positive pressure and ducts conveying moisture-laden or waste-heat-laden air shall be constructed, joined and sealed in an approved manner.

29.6.5.4.2 Type II terminations. Exhaust outlets serving Type II hoods shall terminate in accordance with the hood manufacturer’s installation instructions and shall comply with all of the following:

1. Exhaust outlets shall terminate not less than 914 mm (3 feet) in any direction from openings into the building.
2. Outlets shall terminate not less than 3048 mm (10 feet) from property lines or buildings on the same plot.
3. Outlets shall terminate not less than 3048 mm (10 feet) above grade.
4. Outlets that terminate above a roof shall terminate not less than 762 mm (30 inches) above the roof surface.
5. Outlets shall terminate not less than 762 mm (30 inches) from exterior vertical walls.
6. Outlets shall be protected against local weather conditions.
7. Outlets shall not be directed onto walkways.
8. Outlets shall meet the provisions for exterior wall opening protectives in accordance with the Ghana Building Code.

29.6.5.5 Exhaust equipment. Exhaust equipment, including fans and grease reservoirs, shall comply with Clauses 29.6.5.5.1 through 29.6.5.5.6 and shall be of an approved design or shall be listed for the application.

29.6.5.5.1 Exhaust fans. Exhaust fans serving a Type I hood shall be constructed as required for grease ducts in accordance with Clause 506.3.1.1.

**Exception:** Fans listed and labeled in accordance with this Code.

29.6.5.5.1.1 Fan motor. Exhaust fan motors shall be located outside of the exhaust airstream.

29.6.5.5.1.2 In-line fan location. Where enclosed duct systems are connected to in-line fans not located outdoors, the fan shall be located in a room or space having the same fire-resistance rating as the duct enclosure. Access shall be provided for servicing and cleaning of fan components. Such rooms or spaces shall be ventilated in accordance with the fan manufacturer’s installation instructions.

29.6.5.5.2 Pollution-control units. The installation of pollution-control units shall be in accordance with the manufacturer’s installation instructions and all of the following:

1. Pollution-control units shall be listed and labeled in accordance with this Code.
2. Fans serving pollution-control units shall be listed and labeled in accordance with this Code.
3. Pollution-control units shall be mounted and secured in accordance with the manufacturer’s installation instructions and the Ghana Building Code.
4. Pollution-control units located indoors shall be listed and labeled for such use. Where enclosed duct systems, as required by Clause...
29.6.5.3.11, are connected to a pollution control unit, such unit shall be located in a room or space having the same fire-resistance rating as the duct enclosure. Access shall be provided for servicing and cleaning of the unit. The space or enclosure shall be ventilated in accordance with the manufacturer’s installation instructions.

5. A clearance of not less than 457 mm (18 inches) shall be maintained between the pollution-control unit and combustible material.

6. Roof-mounted pollution-control units shall be listed for outdoor installation and shall be mounted not less than 457 mm (18 inches) above the roof.

7. Exhaust outlets for pollution-control units shall be in accordance with Clause 29.6.5.3.13.

8. An airflow differential pressure control shall be provided to monitor the pressure drop across the filter clauses of a pollution-control unit. When the airflow is reduced below the design velocity, the airflow differential pressure control shall activate a visual alarm located in the area where cooking operations occur.

9. Pollution-control units shall be provided with a factory-installed fire suppression system.

10. Service space shall be provided in accordance with the manufacturer’s instructions for the pollution-control unit and the requirements of this Code.

11. Wash-down drains shall discharge through a grease interceptor and shall be sized for the flow. Drains, shall be sealed with a trap or other approved means to prevent air bypass. Where a trap is utilized it shall have a seal depth that accounts for the system pressurization and evaporation between cleanings.

12. Protection from freezing shall be provided for the water supply and fire suppression systems where such systems are subject to freezing.

13. Duct connections to pollution-control units shall be in accordance with Clause 29.6.5.3.2.3. Where water splash or carryover can occur in the transition duct as a result of a washing operation, the transition duct shall slope downward toward the cabinet drain pan for a length not less than 457 mm (18 inches). Ducts shall transition to the full size of the unit’s inlet and outlet openings.

14. Extra-heavy-duty appliance exhaust systems shall not be connected to pollution-control units except where such units are specifically designed and listed for use with solid fuels.

15. Pollution-control units shall be maintained in accordance with the manufacturer’s instructions.

29.6.5.5.3 Exhaust fan discharge.

Exhaust fans shall be positioned so that the discharge will not impinge on the roof, other equipment or appliances or parts of the structure. A vertical discharge fan shall be manufactured with an approved drain outlet at the lowest point of the housing to permit drainage of grease to an approved grease reservoir.

29.6.5.5.4 Exhaust fan mounting.

Up-blast fans serving Type I hoods and installed in a vertical or horizontal position shall be hinged, supplied with a flexible weatherproof electrical cable to permit inspection and cleaning and shall be equipped with a means of restraint to limit the swing of the fan on its hinge. The ductwork shall extend not less than 457 mm (18 inches) above the roof surface.

29.6.5.5.5 Clearances.

Exhaust equipment serving a Type I hood shall have a clearance to combustible construction of not less than 457 mm (18 inches).
Exception: Factory-built exhaust equipment installed in accordance with this Code and listed for a lesser clearance.

29.6.5.6 Termination location.
The outlet of exhaust equipment serving Type I hoods shall be in accordance with Clause 29.6.5.3.13.

Exception: The minimum horizontal distance between vertical discharge fans and parapet-type building structures shall be 610 mm (2 feet) provided that such structures are not higher than the top of the fan discharge opening.

29.6.6 COMMERCIAL KITCHEN HOODS

29.6.6.1 General.

Commercial kitchen exhaust hoods shall comply with the requirements of this clause. Hoods shall be Type I or II and shall be designed to capture and confine cooking vapors and residues. A Type I or Type II hood shall be installed at or above appliances in accordance with Clauses 29.6.6.2 and 29.6.6.3. Where any cooking appliance under a single hood requires a Type I hood, a Type I hood shall be installed. Where a Type II hood is required, a Type I or Type II hood shall be installed. Where a Type I hood is installed, the installation of the entire system, including the hood, ducts, exhaust equipment and makeup air system shall comply with the requirements of Clauses 29.6.5, 29.6.6, and this Code.

Exceptions:

1. Factory-built commercial exhaust hoods that are listed and labeled in accordance with this Code, and installed in accordance with Clause 3.4.1, shall not be required to comply with Clauses 29.6.6.1.5, 29.6.6.2.3, 29.6.6.2.5, 29.6.6.2.8, 29.6.6.3.1, 29.6.6.3.3, 29.6.6.4 and 29.6.6.5.

2. Factory-built commercial cooking recirculating systems that are listed and labeled in accordance with this Code, and installed in accordance with Clause 3.4.1, shall not be required to comply with Clauses 29.6.6.1.5, 29.6.6.2.3, 29.6.6.2.5, 29.6.6.2.8, 29.6.6.3.1, 29.6.6.3.3, 29.6.6.4 and 29.6.6.5. Spaces in which such systems are located shall be considered to be kitchens and shall be ventilated in accordance with Table 4.3.3.1.1. For the purpose of determining the floor area required to be ventilated, each individual appliance shall be considered as occupying not less than 100 square feet (9.3 m²).

3. Where cooking appliances are equipped with integral down-draft exhaust systems and such appliances and exhaust systems are listed and labeled for the application in accordance with the Ghana Fire Code, a hood shall not be required at or above them.

29.6.6.1.1 Operation.

Commercial kitchen exhaust hood systems shall operate during the cooking operation. The hood exhaust rate shall comply with the listing of the hood or shall comply with Clause 29.6.6.5. The exhaust fan serving a Type I hood shall have automatic controls that will activate the fan when any appliance that requires such Type I Hood is turned on, or a means of interlock shall be provided that will prevent operation of such appliances when the exhaust fan is not turned on. Where one or more temperature or radiant energy sensors are used to activate a Type I hood exhaust fan, the fan shall activate not more than 15 minutes after the first appliance served by that hood has been turned on. A method of interlock between an exhaust hood system and appliances equipped with standing piplot burners shall not cause the piplot burners to be extinguished. A method of interlock between an exhaust hood system and cooking appliances shall not involve or depend on any component of a fire-extinguishing system.

The net exhaust volumes for hoods shall be permitted to be reduced during part-load cooking conditions, where engineered or listed multispeed or variable speed controls automatically operate the exhaust system to maintain capture and removal of cooking effluents as required by this clause. Reduced volumes shall not be below that required to maintain capture and removal of effluents from the idle cooking appliances that are operating in a standby mode.

29.6.6.1.1.1 Multiple hoods utilizing a single exhaust system.

Where heat or radiant energy sensors are utilized in hood systems consisting of multiple
hoods served by a single exhaust system, such sensors shall be provided in each hood. Sensors shall be capable of being accessed from the hood outlet or from a cleanout location.

29.6.6.1.2 Domestic cooking appliances used for commercial purposes.
Domestic cooking appliances utilized for commercial purposes shall be provided with Type I or Type II hoods as required for the type of appliances and processes in accordance with Clauses 29.6.6.2 and 29.6.6.3. Domestic cooking appliances utilized for domestic cooking shall comply with Clause 505.

29.6.6.1.3 Fuel-burning appliances.
Where vented fuel-burning appliances are located in the same room or space as the hood, provisions shall be made to prevent the hood system from interfering with normal operation of the appliance vents.

29.6.6.1.4 Cleaning.
A hood shall be designed to provide for thorough cleaning of the entire hood.

29.6.6.1.5 Exhaust outlets.
Exhaust outlets located within the hood shall be located so as to optimize the capture of particulate matter. Each outlet shall serve not more than a 3658 mm (12-foot) clause of hood.

29.6.6.2 Type I hoods.
Type I hoods shall be installed where cooking appliances produce grease or smoke as a result of the cooking process. Type I hoods shall be installed over medium-duty, heavy-duty and extra-heavy-duty cooking appliances.

Exception: A Type I hood shall not be required for an electric cooking appliance where an approved testing agency provides documentation that the appliance effluent contains 5 mg/m³ or less of grease when tested at an exhaust flow rate of 0.236 m³/s (500 cfm) in accordance with UL 710B.

29.6.6.2.1 Type I exhaust flow rate label.
Type I hoods shall bear a label indicating the minimum exhaust flow rate in cfm per linear foot (1.55 L/s per linear meter) of hood that provides for capture and containment of the exhaust effluent for the cooking appliances served by the hood, based on the cooking appliance duty classifications defined in this Code.

29.6.6.2.2 Type I extra-heavy-duty.
Type I hoods for use over extra-heavy-duty cooking appliances shall not cover heavy-, medium- or light-duty appliances. Such hoods shall discharge to an exhaust system that is independent of other exhaust systems.

29.6.6.2.3 Type I materials.
Type I hoods shall be constructed of steel having a minimum thickness of 0.0466 inch (1.181 mm) (No. 18 gage) or stainless steel not less than 0.0335 inch (0.8525 mm (No. 20 MSG)) in thickness.

29.6.6.2.4 Type I supports.
Type I hoods shall be secured in place by noncombustible supports. Type I hood supports shall be adequate for the applied load of the hood, the unsupported ductwork, the effluent loading and the possible weight of personnel working in or on the hood.

29.6.6.2.5 Type I hoods.
External hood joints, seams and penetrations for Type I hoods shall be made with a continuous external liquid-tight weld or braze to the lowest outermost perimeter of the hood. Internal hood joints, seams, penetrations, filter support frames and other appendages attached inside the hood shall not be required to be welded or brazed but shall be otherwise sealed to be grease tight.

Exceptions:

1. Penetrations shall not be required to be welded or brazed where sealed by devices that are listed for the application.

2. Internal welding or brazing of seams, joints and penetrations of the hood shall not be prohibited provided that the joint is formed smooth or ground so as to not trap grease, and is readily cleanable.

29.6.6.2.6 Clearances for Type I hood.
A Type I hood shall be installed with a clearance to combustibles of not less than 457 mm (18 inches).

Exceptions:
1. Clearance shall not be required from gypsum wallboard or 12.7 mm (\(\frac{1}{2}\) inch) or thicker cementitious wallboard attached to noncombustible structures provided that a smooth, cleanable, nonabsorbent and noncombustible material is installed between the hood and the gypsum or cementitious wallboard over an area extending not less than 457 mm (18 inches) in all directions from the hood.

2. Type I hoods listed and labeled for clearances less than 18 inches in accordance with this Code shall be installed with the clearances specified by such listings.

29.6.6.2.7 Type I hoods penetrating a ceiling.

Type I hoods or portions thereof penetrating a ceiling, wall or furred space shall comply with Clause 29.6.5.3.11. Field-applied grease duct enclosure systems, as addressed in Clause 29.6.5.3.11.2, shall not be utilized to satisfy the requirements of this clause.

29.6.6.2.8 Type I grease filters.

Type I hoods shall be equipped with grease filters listed and labeled in accordance with this Code. Grease filters shall be provided with access for cleaning or replacement. The lowest edge of a grease filter located above the cooking surface shall be not less than the height specified in Table 29.6.6.2.8.

TABLE 29.6.6.2.8
MINIMUM DISTANCE BETWEEN THE LOWEST EDGE OF A GREASE FILTER AND THE COOKING SURFACE OR THE HEATING SURFACE

<table>
<thead>
<tr>
<th>TYPE OF COOKING APPLIANCES</th>
<th>HEIGHT ABOVE COOKING SURFACE (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without exposed flame</td>
<td>0.5</td>
</tr>
<tr>
<td>Exposed flame and burners</td>
<td>2</td>
</tr>
<tr>
<td>Exposed charcoal and charbroil type</td>
<td>3.5</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm.

29.6.6.2.8.1 Criteria.

Filters shall be of such size, type and arrangement as will permit the required quantity of air to pass through such units at rates not exceeding those for which the filter or unit was designed or approved. Filter units shall be installed in frames or holders so as to be readily removable without the use of separate tools, unless designed and installed to be cleaned in place and the system is equipped for such cleaning in place. Where filters are designed and required to be cleaned, removable filter units shall be of a size that will allow them to be cleaned in a dishwashing machine or pot sink. Filter units shall be arranged in place or provided with drip-intercepting devices to prevent grease or other condensate from dripping into food or on food preparation surfaces.

29.6.6.2.8.2 Mounting position of grease filters.

Filters shall be installed at an angle of not less than 45 degrees (0.79 rad) from the horizontal and shall be equipped with a drip tray beneath the lower edge of the filters.

29.6.6.2.9 Grease gutters for Type I hood.

Grease gutters shall drain to an approved collection receptacle that is fabricated, designed and installed to allow access for cleaning.

29.6.6.3 Type II hoods.

Type II hoods shall be installed above dishwashers and appliances that produce heat or moisture and do not produce grease or smoke as a result of the cooking process, except where the heat and moisture loads from such appliances are incorporated into the HVAC system design or into the design of a separate removal system. Type II hoods shall be installed above all appliances that produce products of combustion and do not produce grease or smoke as a result of the cooking process. Spaces containing cooking appliances that do not require Type II hoods shall be provided with exhaust at a rate of 0.70 cfm per square foot (0.00033 m\(^3\)/s). For the purpose of determining the floor area required to be exhausted, each individual appliance that is not required to be installed under a Type II hood shall be considered as occupying 9.3 m\(^2\) (100 square feet). Such additional square footage shall be provided...
with exhaust at a rate of 0.70 cfm per square foot \( \frac{3}{0.00356 \text{ m}^3/(s \cdot \text{m}^2)} \).

### 29.6.6.3 Type II hood materials.

Type II hoods shall be constructed of steel having a minimum thickness of 0.0296 inch (0.7534 mm) (No. 22 gage) or stainless steel not less than 0.5550 mm (0.0220 inch) (No. 24 gage) in thickness, copper sheets weighing not less than 24 ounces per square foot (7.3 kg/m \(^2\)) or of other approved material and gage.

### 29.6.6.3.2 Type II supports.

Type II hood supports shall be adequate for the applied load of the hood, the unsupported ductwork, the effluent loading and the possible weight of personnel working in or on the hood.

### 29.6.6.3.3 Type II hoods joint, seams and penetrations.

Joints, seams and penetrations for Type II hoods shall be constructed as set forth in this Code shall be sealed on the interior of the hood and shall provide a smooth surface that is readily cleanable and water tight.

### 29.6.6.4 Hood size and location.

Hoods shall comply with the overhang, setback and height requirements in accordance with Clauses 29.6.6.4.1 and 29.6.6.4.2, based on the type of hood.

#### 29.6.6.4.1 Canopy size and location.

The inside lower edge of canopy-type Type I and II commercial hoods shall overhang or extend a horizontal distance of not less than 152 mm (6 inches) beyond the edge of the top horizontal surface of the appliance on all open sides. The vertical distance between the front lower lip of the hood and such surface shall not exceed 1219 mm (4 feet).

**Exception:** The hood shall be permitted to be flush with the outer edge of the cooking surface where the hood is closed to the appliance side by a noncombustible wall or panel.

### 29.6.6.4.2 Noncanopy size and location.

Noncanopy-type hoods shall be located not greater than 914 mm (3 feet) above the cooking surface. The edge of the hood shall be set back not greater than 1 foot (305 mm) from the edge of the cooking surface.

### 29.6.6.5 Capacity of hoods.

Commercial food service hoods shall exhaust a minimum net quantity of air determined in accordance with this clause and Clauses 29.6.6.5.1 through 29.6.6.5.5. The net quantity of exhaust air shall be calculated by subtracting any airflow supplied directly to a hood cavity from the total exhaust flow rate of a hood. Where any combination of heavy-duty, medium-duty and light-duty cooking appliances are utilized under a single hood, the exhaust rate required by this clause for the heaviest duty appliance covered by the hood shall be used for the entire hood.

#### 29.6.6.5.1 Extra-heavy-duty cooking appliances.

The minimum net airflow for hoods, as determined by Clause 29.6.6.1, used for extra-heavy-duty cooking appliances shall be determined as follows:

<table>
<thead>
<tr>
<th>Type of Hood</th>
<th>CFM per linear foot of hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>550</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>700</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>550</td>
</tr>
</tbody>
</table>

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

### 29.6.6.5.2 Heavy-duty cooking appliances.

The minimum net airflow for hoods, as determined by Clause 29.6.6.1, used for heavy-duty cooking appliances shall be determined as follows:

<table>
<thead>
<tr>
<th>Type of Hood</th>
<th>CFM per linear foot of hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>400</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>400</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>600</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>400</td>
</tr>
</tbody>
</table>

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

### 29.6.6.5.3 Medium-duty cooking appliances.

The minimum net airflow for hoods, as determined by Clause 29.6.6.1, used for
medium-duty cooking appliances shall be determined as follows:

<table>
<thead>
<tr>
<th>Type of Hood</th>
<th>CFM per linear foot of hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>300</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>300</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>250</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>500</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>300</td>
</tr>
</tbody>
</table>

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

29.6.6.5.4 Light-duty cooking appliances.
The minimum net airflow for hoods, as determined by Clause 29.6.6.1, used for light-duty cooking appliances and food service preparation shall be determined as follows:

<table>
<thead>
<tr>
<th>Type of Hood</th>
<th>CFM per linear foot of hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>250</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>250</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>250</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>400</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>200</td>
</tr>
</tbody>
</table>

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

29.6.6.5 Dishwashing appliances.
The minimum net airflow for Type II hoods used for dishwashing appliances shall be 100 cfm per linear foot (155 L/s per linear meter) of hood length.

29.6.6.6 Performance test.
A performance test shall be conducted upon completion and before final approval of the installation of a ventilation system serving commercial cooking appliances. The test shall verify the rate of exhaust airflow required by Clause 29.6.6.5, makeup airflow required by Clause 29.6.7 and proper operation as specified in this part. The permit holder shall furnish the necessary test equipment and devices required to perform the tests.

29.6.6.6.1 Capture and containment test.
The permit holder shall verify capture and containment performance of the exhaust system. This field test shall be conducted with all appliances under the hood at operating temperatures, with all sources of outdoor air providing makeup air for the hood operating and with all sources of recirculated air providing conditioning for the space in which the hood is located operating. Capture and containment shall be verified visually by observing smoke or steam produced by actual or simulated cooking, such as that provided by smoke candles and smoke puffers. Smoke bombs shall not be used.

29.6.7 COMMERCIAL KITCHEN MAKEUP AIR

29.6.7.1 Makeup air.
Makeup air shall be supplied during the operation of commercial kitchen exhaust systems that are provided for commercial cooking appliances. The amount of makeup air supplied to the building from all sources shall be approximately equal to the amount of exhaust air for all exhaust systems for the building. Makeup air shall not reduce the effectiveness of the exhaust system. Makeup air shall be provided by gravity or mechanical means or both. Mechanical makeup air systems shall be automatically controlled to start and operate simultaneously with the exhaust system. Makeup air intake opening locations shall comply with Clause 401.4.

29.6.7.1.1 Makeup air temperature.
The temperature differential between makeup air and the air in the conditioned space shall not exceed 10°F (6°C) except where the added heating and cooling loads of the makeup air do not exceed the capacity of the HVAC system.

29.6.7.1.2 Air balance.
Design plans for a facility with a commercial kitchen ventilation system shall include a schedule or diagram indicating the design outdoor air balance. The design outdoor air balance shall indicate all exhaust and replacement air for the facility, plus the net exfiltration if applicable. The total replacement air airflow rate shall equal the total exhaust airflow rate plus the net exfiltration.
29.6.7.2 Compensating hoods.
Manufacturers of compensating hoods shall provide a label indicating the minimum exhaust flow, the maximum makeup airflow or both that provides capture and containment of the exhaust effluent.

Exception: Compensating hoods with makeup air supplied only from the front face discharge and side face discharge openings shall not be required to be labeled with the maximum makeup airflow.

29.6.8 FIRE SUPPRESSION SYSTEMS

29.6.8.1 Where required.
Cooking appliances required by Clause 29.6.6.2 to have a Type I hood shall be provided with an approved automatic fire suppression system complying with the Ghana Building Code and the Ghana Fire Code.

29.6.9 HAZARDOUS EXHAUST SYSTEMS

29.6.9.1 General.
This clause shall govern the design and construction of duct systems for hazardous exhaust and shall determine where such systems are required. Hazardous exhaust systems are systems designed to capture and control hazardous emissions generated from product handling or processes, and convey those emissions to the outdoors. Hazardous emissions include flammable vapours, gases, fumes, mists or dusts, and volatile or airborne materials posing a health hazard, such as toxic or corrosive materials. For the purposes of this clause, the health-hazard rating of materials shall be as specified in the Ghana Fire Code.

For the purposes of the provisions of Clause 29.6.9, a laboratory shall be defined as a facility where the use of chemicals is related to testing, analysis, teaching, research or developmental activities. Chemicals are used or synthesized on a nonproduction basis, rather than in a manufacturing process.

29.6.9.2 Where required.
A hazardous exhaust system shall be required wherever operations involving the handling or processing of hazardous materials, in the absence of such exhaust systems and under normal operating conditions, have the potential to create one of the following conditions:

1. A flammable vapour, gas, fume, mist or dust is present in concentrations exceeding 25 percent of the lower flammability limit of the substance for the expected room temperature.

2. A vapour, gas, fume, mist or dust with a health-hazard rating of 4 is present in any concentration.

3. A vapour, gas, fume, mist or dust with a health-hazard rating of 1, 2 or 3 is present in concentrations exceeding 1 percent of the median lethal concentration of the substance for acute inhalation toxicity.

Exception: Laboratories, as defined in Clause 29.6.9.1, except where the concentrations listed in Item 1 are exceeded or a vapour, gas, fume, mist or dust with a health-hazard rating of 1, 2, 3 or 4 is present in concentrations exceeding 1 percent of the median lethal concentration of the substance for acute inhalation toxicity.

29.6.9.2.1 Timber yards and woodworking facilities.
Equipment or machinery located inside buildings at timber yards and woodworking facilities that generates or emits combustible dust shall be provided with an approved dust-collection and exhaust system installed in accordance with this clause and the Ghana Fire Code. Equipment and systems that are used to collect, process or convey combustible dusts shall be provided with an approved explosion-control system.

29.6.9.2.2 Combustible fibers.
Equipment or machinery within a building that generates or emits combustible fibers shall be provided with an approved dust-collecting exhaust system. Such systems shall comply with this Code and the Ghana Fire Code.

29.6.9.3 Design and operation.
The design and operation of the exhaust system shall be such that flammable contaminants are diluted in noncontaminated air to maintain concentrations in the exhaust flow below 25 percent of the contaminant’s lower flammability limit.
29.6.9.4 Independent system.
Hazardous exhaust systems shall be independent of other types of exhaust systems.

29.6.9.5 Incompatible materials and common shafts.
Incompatible materials, as defined in the Ghana Fire Code, shall not be exhausted through the same hazardous exhaust system. Hazardous exhaust systems shall not share common shafts with other duct systems, except where such systems are hazardous exhaust systems originating in the same fire area.

Exception: The provisions of this clause shall not apply to laboratory exhaust systems where all of the following conditions apply:

1. All of the hazardous exhaust ductwork and other laboratory exhaust within both the occupied space and the shafts are under negative pressure while in operation.

2. The hazardous exhaust ductwork manifolded together within the occupied space must originate within the same fire area.

3. Hazardous exhaust ductwork originating in different fire areas and manifolded together in a common shaft shall meet the provisions of Clause 717.5.3, Exception 1, Item 1.1 of the In this Code.

4. Each control branch has a flow regulating device.

5. Perchloric acid hoods and connected exhaust shall be prohibited from manifolding.

6. Radioisotope hoods are equipped with filtration, carbon beds or both where required by the registered design professional.

7. Biological safety cabinets are filtered.

8. Each hazardous exhaust duct system shall be served by redundant exhaust fans that comply with either of the following:

8.1. The fans shall operate simultaneously in parallel and each fan shall be individually capable of providing the required exhaust rate.

8.2. Each of the redundant fans is controlled so as to operate when the other fan has failed or is shut down for servicing.

29.6.9.6 Design.
Systems for removal of vapours, gases and smoke shall be designed by the constant velocity or equal friction methods. Systems conveying particulate matter shall be designed employing the constant velocity method.

29.6.9.6.1 Balancing.
Systems conveying explosive or radioactive materials shall be prebalanced by duct sizing. Other systems shall be balanced by duct sizing with balancing devices, such as dampers. Dampers provided to balance airflow shall have securely fixed minimum-position blocking devices to prevent restricting the flow below the required volume or velocity.

29.6.9.6.2 Emission control.
The design of the system shall be such that the emissions are confined to the area in which they are generated by air currents, hoods or enclosures and shall be exhausted by a duct system to a safe location or treated by removing contaminants.

29.6.9.6.3 Hoods required.
Hoods or enclosures shall be used where contaminants originate in a limited area of a space. The design of the hood or enclosure shall be such that air currents created by the exhaust systems will capture the contaminants and transport them directly to the exhaust duct.

29.6.9.6.4 Contaminant capture and dilution.
The velocity and circulation of air in work areas shall be such that contaminants are
captured by an airstream at the area where the emissions are generated and conveyed into a product-conveying duct system. Contaminated air from work areas where hazardous contaminants are generated shall be diluted below the thresholds specified in Clause 29.6.9.2 with air that does not contain other hazardous contaminants.

29.6.9.6.5 Makeup air.
Makeup air shall be provided at a rate approximately equal to the rate that air is exhausted by the hazardous exhaust system. Makeup air intakes shall be located in accordance with this Code.

29.6.9.6.6 Clearances.
The minimum clearance between hoods and combustible construction shall be the clearance required by the duct system.

29.6.9.6.7 Ducts.
Hazardous exhaust duct systems shall extend directly to the exterior of the building and shall not extend into or through ducts and plenums.

29.6.9.7 Penetrations.
Penetrations of structural elements by a hazardous exhaust system shall conform to Clauses 29.6.9.7.1 through 29.6.9.7.4.

Exception: Duct penetrations within Group H-5 occupancies as allowed by the Ghana Building Code.

29.6.9.7.1 Fire dampers and smoke dampers.
Fire dampers and smoke dampers are prohibited in hazardous exhaust ducts.

29.6.9.7.1.1 Shaft penetrations.
Hazardous exhaust ducts that penetrate fire-resistance-rated shafts shall comply with this Code.

29.6.9.7.2 Floors.
Hazardous exhaust systems that penetrate a floor/ceiling assembly shall be enclosed in a fire-resistance-rated shaft constructed in accordance with the In this Code.

29.6.9.7.3 Wall assemblies.
Hazardous exhaust duct systems that penetrate fire-resistance-rated wall assemblies shall be enclosed in fire-resistance-rated construction from the point of penetration to the outlet terminal, except where the interior of the duct is equipped with an approved automatic fire suppression system. Ducts shall be enclosed in accordance with the In this Code requirements for shaft construction and such enclosure shall have a minimum fire-resistance rating of not less than the highest fire-resistance-rated wall assembly penetrated.

29.6.9.7.4 Fire walls.
Ducts shall not penetrate a fire wall.

29.6.9.8 Suppression required.
Ducts shall be protected with an approved automatic fire suppression system installed in accordance with the Ghana Building Code.

Exceptions:

1. An approved automatic fire suppression system shall not be required in ducts conveying materials, fumes, mists and vapours that are nonflammable and noncombustible under all conditions and at any concentrations.

2. Automatic fire suppression systems shall not be required in metallic and noncombustible, nonmetallic exhaust ducts in semiconductor fabrication facilities.

3. An approved automatic fire suppression system shall not be required in ducts where the largest cross-clauseal diameter of the duct is less than 10 inches (254 mm).

4. For laboratories, as defined in Clause 29.6.9.1, automatic fire protection systems shall not be required in laboratory hoods or exhaust systems.

29.6.9.8.1 Duct cleanout.
Ducts conveying combustible dust as part of a dust collection system shall be equipped with cleanouts that are provided with approved access, predesigned to be disassembled for cleaning, or engineered for automatic cleanouts. Where provided, cleanouts shall be located at the base of each vertical duct riser and at intervals not exceeding 6096 mm (20 feet) in horizontal clauses of duct.

29.6.9.9 Duct construction.
Ducts used to convey hazardous exhaust shall
be constructed of materials approved for installation in such an exhaust system and shall comply with one of the following:

1. Ducts shall be constructed of approved G90 galvanized sheet steel, with a minimum nominal thickness as specified in Table 29.6.9.9.

2. Ducts used in systems exhausting nonflammable corrosive fumes or vapours shall be constructed of nonmetallic materials that exhibit a flame spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E84 and that are listed and labeled for the application.

Where the products being exhausted are detrimental to the duct material, the ducts shall be constructed of alternative materials that are compatible with the exhaust.

### TABLE 29.6.9.9

<table>
<thead>
<tr>
<th>DIAMETER OF DUCT OR MAXIMUM SIDE DIMENSION</th>
<th>MINIMUM NOMINAL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonabrasive materials</td>
</tr>
<tr>
<td>0–8 inches</td>
<td>0.028 inch (No. 24 gage)</td>
</tr>
<tr>
<td>9–18 inches</td>
<td>0.034 inch (No. 22 gage)</td>
</tr>
<tr>
<td>19–30 inches</td>
<td>0.040 inch (No. 20 gage)</td>
</tr>
<tr>
<td>Over 30 inches</td>
<td>0.052 inch (No. 18 gage)</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

### 29.6.9.9.2 Clearance to combustibles.

Ducts shall have a clearance to combustibles in accordance with Table 29.6.9.9.2. Exhaust gases having temperatures in excess of 600°F (316°C) shall be exhausted to a chimney in accordance with Clause 29.6.10.2.

### TABLE 29.6.9.9.2

<table>
<thead>
<tr>
<th>TYPE OF EXHAUST OR TEMPERATURE OF EXHAUST (°F)</th>
<th>CLEARANCE TO COMBUSTIBLES (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100</td>
<td>1</td>
</tr>
<tr>
<td>100–600</td>
<td>12</td>
</tr>
<tr>
<td>Flammable vapours</td>
<td>6</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, °C =[(°F) - 32]/1.8.

### 29.6.9.9.3 Explosion relief.

Systems exhausting potentially explosive mixtures shall be protected with an approved explosion relief system or by an approved explosion prevention system designed and installed in accordance the Ghana Fire Code. An explosion relief system shall be designed to minimize the structural and mechanical damage resulting from an explosion or deflagration within the exhaust system. An explosion prevention system shall be designed to prevent an explosion or deflagration from occurring.

### 29.6.9.10 Supports.

Ducts shall be supported at intervals not exceeding 3048 mm (10 feet). Supports shall be constructed of noncombustible material.

### 29.6.10 DUST, STOCK AND REFUSE CONVEYING SYSTEMS

#### 29.6.10.1 Dust, stock and refuse conveying systems.

Dust, stock and refuse conveying systems shall comply with the provisions of Clause 29.6.9 and Clauses 29.6.10.1.1 through 29.6.10.2.

#### 29.6.10.1.1 Collectors and separators

Collectors and separators involving such systems as centrifugal separators, bag filter systems and similar devices, and associated supports shall be constructed of noncombustible materials and shall be located on the exterior of the building or structure. A collector or separator shall not be located...
nearer than 3048 mm (10 feet) to combustible construction or to an unprotected wall or floor opening, unless the collector is provided with a metal vent pipe that extends above the highest part of any roof with a distance of 9144 mm (30 feet).

Exceptions:

1. Collectors such as “Point of Use” collectors, close extraction weld fume collectors, spray finishing booths, stationary grinding tables, sanding booths, and integrated or machine-mounted collectors shall be permitted to be installed indoors provided that the installation is in accordance with the Ghana Fire Code and Ghana Wiring Code.

2. Collectors in independent exhaust systems handling combustible dusts shall be permitted to be installed indoors provided that such collectors are installed in compliance with the Ghana Fire Code and Ghana Wiring Code.

29.6.10.1.2 Discharge pipe.
Discharge piping shall conform to the requirements for ducts, including clearances required for high-heat appliances, as contained in this Code. A delivery pipe from a cyclone collector shall not convey refuse directly into the firebox of a boiler, furnace, dutch oven, refuse burner, incinerator or other appliance.

29.6.10.1.3 Conveying systems exhaust discharge.
An exhaust system shall discharge to the outside of the building either directly by flue or indirectly through the bin or vault into which the system discharges except where the contaminants have been removed. Exhaust system discharge shall be permitted to be recirculated provided that the solid particulate has been removed at a minimum efficiency of 99.9 percent at 10 microns (10.01 mm), vapour concentrations are less than 25 percent of the LFL, and approved equipment is used to monitor the vapour concentration.

29.6.10.1.4 Spark protection.
The outlet of an open-air exhaust terminal shall be protected with an approved metal or other noncombustible screen to prevent the entry of sparks.

29.6.10.1.5 Explosion relief vents.
A safety or explosion relief vent shall be provided on all systems that convey combustible refuse or stock of an explosive nature, in accordance with the requirements of the Ghana Building Code.

29.6.10.1.5.1 Screens.
Where a screen is installed in a safety relief vent, the screen shall be attached so as to permit ready release under the explosion pressure.

29.6.10.1.5.2 Hoods.
The relief vent shall be provided with an approved noncombustible cowl or hood, or with a counterbalanced relief valve or cover arranged to prevent the escape of hazardous materials, gases or liquids.

29.6.10.2 Exhaust outlets.
Outlets for exhaust that exceed 600°F (315°C) shall be designed as a chimney in accordance with Table 29.6.10.2.

**TABLE 29.6.10.2**
CONSTRUCTION, CLEARANCE AND TERMINATION REQUIREMENTS FOR SINGLE-WALL METAL CHIMNEYS

<table>
<thead>
<tr>
<th>CHIMNEYS SERVING</th>
<th>MINIMUM THICKNESS</th>
<th>TERMINATION</th>
<th>CLEARANCE</th>
</tr>
</thead>
</table>

1123
### 29.6.11 SUBSLAB SOIL EXHAUST SYSTEMS

#### 29.6.11.1 General.
Where a subslab soil exhaust system is provided, the duct shall conform to the requirements of this clause.

#### 29.6.11.2 Materials.
Subslab soil exhaust system duct material shall be air duct material listed and labeled to the requirements of this Code for Class 0 air ducts, or any of the following piping materials that comply as building sanitary drainage and vent pipe: cast iron; galvanized steel; copper or copper-alloy pipe and tube of a weight not less than type DWV; and plastic piping.

#### 29.6.11.3 Grade.
Exhaust system ducts shall not be trapped and shall have a minimum slope of one-eighth unit vertical in 12 units horizontal (1-percent slope).

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High-heat appliances</td>
<td>0.127 (No. 10 MSG)</td>
<td>1 / 2&quot; laid on 4 / 2&quot; bed</td>
<td>20</td>
<td>—</td>
<td>—</td>
<td>20</td>
<td>See Note c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Over 2,000°F)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-heat appliances</td>
<td>0.127 (No. 10 MSG)</td>
<td>none</td>
<td>3</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>18</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1,000°F normal operation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium-heat appliances</td>
<td>0.127 (No. 10 MSG)</td>
<td>Up to 18&quot; dia.—2 / 2&quot;</td>
<td>10</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>36</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2,000°F maximum)</td>
<td></td>
<td>Over 18&quot;—1 / 2&quot; On 1 / 2&quot; bed</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °C =[(ºF) - 32]/1.8.

a. Lining shall extend from bottom to top of outlet.
b. Lining shall extend from 24 inches below connector to 24 feet above.
c. Clearance shall be as specified by the design engineer and shall have sufficient clearance from buildings and structures to avoid overheating combustible materials (maximum 160°F).

#### 29.6.11.4 Termination.
Subslab soil exhaust system ducts shall extend through the roof and terminate not less than 6 inches (152 mm) above the roof and not less than 10 feet (3048 mm) from any operable openings or air intake.

#### 29.6.11.5 Identification.
Subslab soil exhaust ducts shall be permanently identified within each floor level by means of a tag, stencil or other approved marking.

#### 29.6.12 SMOKE CONTROL SYSTEMS

#### 29.6.12.1 Scope and purpose.
This clause applies to mechanical and passive smoke control systems that are required by the Ghana Building Code or the Ghana Fire Code. The purpose of this clause is to establish minimum requirements for the design, installation and acceptance testing of smoke control systems that are intended to provide a tenable environment for the evacuation or relocation of occupants. These
provisions are not intended for the preservation of contents, the timely restoration of operations, or for assistance in fire suppression or overhaul activities. Smoke control systems regulated by this clause serve a different purpose than the smoke and heat removal provisions found in this Code or the Ghana Fire Code.

29.6.12.2 General design requirements.

Buildings, structures, or parts thereof required by the Ghana Building Code or the Ghana Fire Code to have a smoke control system or systems shall have such systems designed in accordance with good engineering practice and accepted and well-established principles of engineering relevant to the design. The construction documents shall include sufficient information and detail to describe adequately the elements of the design necessary for the proper implementation of the smoke control systems. These documents shall be accompanied with sufficient information and analysis to demonstrate compliance with these provisions.

29.6.12.4 Analysis.

A rational analysis supporting the types of smoke control systems to be employed, their methods of operation, the systems supporting them and the methods of construction to be utilized shall accompany the submitted construction documents and shall include, but not be limited to, the items indicated in Clauses 29.6.12.4.1 through 29.6.12.4.7.

29.6.12.4.1 Stack effect.

The system shall be designed such that the maximum probable normal or reverse stack effects will not adversely interfere with the system’s capabilities. In determining the maximum probable stack effects, altitude, elevation, weather history and interior temperatures shall be used.

29.6.12.4.2 Temperature effect of fire.

Buoyancy and expansion caused by the design fire in accordance with Clause 29.6.12.9 shall be analyzed. The system shall be designed such that these effects do not adversely interfere with its capabilities.

29.6.12.4.3 Wind effect.

The design shall consider the adverse effects of wind. Such consideration shall be consistent with the wind-loading provisions of the Ghana Building Code.

29.6.12.4.4 HVAC systems.

The design shall consider the effects of the heating, ventilating and air-conditioning (HVAC) systems on both smoke and fire transport. The analysis shall include all permutations of systems’ status. The design shall consider the effects of fire on the HVAC systems.

29.6.12.4.5 Climate.

The design shall consider the effects of low temperatures on systems, property and occupants. Air inlets and exhausts shall be located so as to prevent snow or ice blockage.

29.6.12.4.6 Duration of operation.

All portions of active or engineered smoke control systems shall be capable of continued operation after detection of the fire event for a period of not less than either 20 minutes or 1.5 times the calculated egress time, whichever is greater.

29.6.12.4.7 Smoke control system interaction.

The design shall consider the interaction effects of the operation of multiple smoke control systems for all design scenarios.

29.6.12.5.1 Total leakage area.

Total leakage area of the barrier is the product of the smoke barrier gross area times the allowable leakage area ratio, plus the area of other openings such as gaps around doors and operable windows.

29.6.12.5.2 Testing of leakage area.

Compliance with the maximum total leakage area shall be determined by achieving the minimum air pressure difference across the barrier with the system in the smoke control mode for mechanical smoke control systems utilizing the pressurization method. Compliance with the maximum total leakage area of passive smoke control systems shall be verified through methods such as door fan testing or other methods, as approved by the fire Code official.

29.6.12.5.3 Opening protection.

Openings in smoke barriers shall be protected by automatic-closing devices actuated by the required controls for the mechanical smoke control system. Door openings shall be protected by door assemblies complying with the requirements of the Ghanaian Building Code for doors in smoke barriers.
Exceptions:

1. Passive smoke control systems with automatic-closing devices actuated by spot-type smoke detectors listed for releasing service installed in accordance with the Ghana Building Code.

2. Fixed openings between smoke zones that are protected utilizing the airflow method.

3. In Group I-1, Condition 2, Group I-2 and ambulatory care facilities, where a pair of opposite swinging doors are installed across a corridor in accordance with Clause 29.6.12.5.3.1, the doors shall not be required to be protected. The doors shall be close-fitting within operational tolerances and shall not have a center mullion or undercuts in excess of 19.1 mm (3/4 inch), louvers or grilles. The doors shall have head and jamb stops and astragals or rabbets at meeting edges and, where permitted by the door manufacturer's listing, positive-latching devices are not required.

4. Openings between smoke zones with clear ceiling heights of 14 feet (4267 mm) or greater and bank down capacity of greater than 20 minutes as determined by the design fire size.

29.6.12.5.3.1 Group I-1 Condition 2; Group I-2 and ambulatory care facilities.

In Group I-1 Condition 2; Group I-2 and ambulatory care facilities, where doors are installed across a corridor, the doors shall be automatic closing by smoke detection in accordance with the Ghana Building Code and shall have a vision panel with fire-protection-rated glazing materials in fire-protection-rated frames, the area of which shall not exceed that tested.

29.6.12.5.3.2 Ducts and air transfer openings.

Ducts and air transfer openings are required to be protected with a minimum Class II, 250°F (121°C) smoke damper complying with the Ghana Building Code.

29.6.12.6 Pressurization method.

The primary mechanical means of controlling smoke shall be by pressure differences across smoke barriers. Maintenance of a tenable environment is not required in the smoke control zone of fire origin.

29.6.12.6.1 Minimum pressure difference.

The pressure difference across a smoke barrier used to separate smoke zones shall be not less than 0.05-inch water gage (12.4 Pa) in fully sprinklered buildings.

In buildings permitted to be other than fully sprinklered, the smoke control system shall be designed to achieve pressure differences not less than two times the maximum calculated pressure difference produced by the design fire.

29.6.12.6.2 Maximum pressure difference.

The maximum air pressure difference across a smoke barrier shall be determined by required door-opening or closing forces. The actual force required to open exit doors when the system is in the smoke control mode shall be in accordance with the Ghana Building Code. Opening and closing forces for other doors shall be determined by standard engineering methods for the resolution of forces and reactions. The calculated force to set a side-hinged, swinging door in motion shall be determined by:

\[ F = F_{dc} + K(WA\Delta P)/2(W-d) \]  
(Equation 5-2)

where:

- \( A \) = Door area, square feet (m²).
- \( d \) = Distance from door handle to latch edge of door, feet (m).
- \( F \) = Total door opening force, pounds (N).
- \( F_{dc} \) = Force required to overcome closing device, pounds (N).
- \( K \) = Coefficient 5.2 (1.0).
- \( W \) = Door width, feet (m).
- \( \Delta P \) = Design pressure difference, inches (Pa) water gage.

29.6.12.6.3 Pressurized stairways and elevator hoistways.

Where stairways or elevator hoistways are pressurized, such pressurization systems shall comply with Clause 29.6.13 as smoke control systems.

1126
29.6.12.7 Airflow design method.
Where approved by the Code official, smoke migration through openings fixed in a permanently open position, which are located between smoke control zones by the use of the airflow method, shall be permitted. The design airflows shall be in accordance with this clause. Airflow shall be directed to limit smoke migration from the fire zone. The geometry of openings shall be considered to prevent flow reversal from turbulent effects. Smoke control systems using the airflow method shall be designed in accordance with the Ghana Fire Code.

29.6.12.7.1 Prohibited conditions.
This method shall not be employed where either the quantity of air or the velocity of the airflow will adversely affect other portions of the smoke control system, unduly intensify the fire, disrupt plume dynamics or interfere with exiting. Airflow toward the fire shall not exceed 200 feet per minute (1.02 m/s). Where the calculated airflow exceeds this limit, the airflow method shall not be used.

29.6.12.8 Exhaust method.
Where approved by the building official, mechanical smoke control for large enclosed volumes, such as in atriums or malls, shall be permitted to utilize the exhaust method. Smoke control systems using the exhaust method shall be designed in accordance with the Ghana Fire Code.

29.6.12.8.1 Exhaust rate.
The height of the lowest horizontal surface of the accumulating smoke layer shall be maintained not less than 6 feet (1829 mm) above any walking surface that forms a portion of a required egress system within the smoke zone.

29.6.12.9 Design fire.
The design fire shall be based on a rational analysis performed by the registered design professional and approved by the Code official. The design fire shall be based on the analysis in accordance with Clause 29.6.12.4 and this clause.

29.6.12.9.1 Factors considered.
The engineering analysis shall include the characteristics of the fuel, fuel load, effects included by the fire and whether the fire is likely to be steady or unsteady.

29.6.12.9.2 Design fire fuel.
Determination of the design fire shall include consideration of the type of fuel, fuel spacing and configuration.

29.6.12.9.3 Heat-release assumptions.
The analysis shall make use of the best available data from approved sources and shall not be based on excessively stringent limitations of combustible material.

29.6.12.9.4 Sprinkler effectiveness assumptions.
A documented engineering analysis shall be provided for conditions that assume fire growth is halted at the time of sprinkler activation.

29.6.12.10 Equipment.
Equipment such as, but not limited to, fans, ducts, automatic dampers and balance dampers shall be suitable for their intended use, suitable for the probable exposure temperatures that the rational analysis indicates, and as approved by the Code official.

29.6.12.10.1 Exhaust fans.
Components of exhaust fans shall be rated and certified by the manufacturer for the probable temperature rise to which the components will be exposed. This temperature rise shall be computed by:

$$T_s = \left(\frac{Q_c}{mc}\right) + T_a$$

(Equation 5-3)

where:

- $c$ = Specific heat of smoke at smoke-layer temperature, Btu/lb°F (kJ/kg • K).
- $m$ = Exhaust rate, pounds per second (kg/s).
- $Q_c$ = Convective heat output of fire, Btu/s (kW).
- $T_a$ = Ambient temperature,°F (K).
- $T_s$ = Smoke temperature,°F (K).

Exception: Reduced $T_s$ as calculated based on the assurance of adequate dilution air.

29.6.12.10.2 Ducts.
Duct materials and joints shall be capable of withstanding the probable temperatures and pressures to which they are exposed as determined in accordance with Clause 29.6.12.10.1. Ducts shall be leak tested to 1.5 times the maximum design pressure in accordance with nationally accepted practices. Measured leakage shall not exceed 5 percent of design flow. Results of such testing shall be
a part of the documentation procedure. Ducts shall be supported directly from fire-resistance-rated structural elements of the building by substantial, noncombustible supports.

**Exception:** Flexible connections, for the purpose of vibration isolation, that are constructed of approved fire-resistance-rated materials.

### 29.6.12.10.3 Equipment, inlets and outlets.

Equipment shall be located so as to not expose uninvolved portions of the building to an additional fire hazard. Outdoor air inlets shall be located so as to minimize the potential for introducing smoke or flame into the building. Exhaust outlets shall be so located as to minimize reintroduction of smoke into the building and to limit exposure of the building or adjacent buildings to an additional fire hazard.

### 29.6.12.10.4 Automatic dampers.

Automatic dampers, regardless of the purpose for which they are installed within the smoke control system, shall be listed and conform to the requirements of approved recognized standards.

### 29.6.12.10.5 Fans.

In addition to other requirements, belt-driven fans shall have 1.5 times the number of belts required for the design duty with the minimum number of belts being two. Fans shall be selected for stable performance based on normal temperature and, where applicable, elevated temperature. Calculations and manufacturer’s fan curves shall be part of the documentation procedures. Fans shall be supported and restrained by noncombustible devices in accordance with the structural design requirements of the Ghana Building Code. Motors driving fans shall not be operating beyond their nameplate horsepower (kilowatts) as determined from measurement of actual current draw. Motors driving fans shall have a minimum service factor of 1.15.

### 29.6.12.11 Standby power.

The smoke control system shall be supplied with standby power in accordance with this Code.

#### 29.6.12.11.1 Equipment room.

The standby power source and its transfer switches shall be in a room separate from the normal power transformers and switch gear and ventilated directly to and from the exterior. The room shall be enclosed with not less than 1-hour fire-resistance-rated fire barriers constructed in accordance with this Code.

### 29.6.12.11.2 Power sources and power surges.

Elements of the smoke management system relying on volatile memories or the like shall be supplied with uninterruptible power sources of sufficient duration to span 15-minute primary power interruption. Elements of the smoke management system susceptible to power surges shall be suitably protected by conditioners, suppressors or other approved means.

### 29.6.12.12 Detection and control systems.

Fire detection systems providing control input or output signals to mechanical smoke control systems or elements thereof shall comply with the requirements of Part 8 of the Ghana Building Code. Such systems shall be equipped with a control unit complying with this Code and listed as smoke control equipment.

#### 29.6.12.12.1 Verification.

Control systems for mechanical smoke control systems shall include provisions for verification. Verification shall include positive confirmation of actuation, testing, manual override and the presence of power downstream of all disconnects. A preprogrammed weekly test sequence shall report abnormal conditions audibly, visually and by printed report. The preprogrammed weekly test shall operate all devices, equipment and components used for smoke control.

**Exception:** Where verification of individual components tested through the preprogrammed weekly testing sequence will interfere with, and produce unwanted effects to, normal building operation, such individual components are permitted to be bypassed from the preprogrammed weekly testing, where approved by the building official and in accordance with both of the following:

1. Where the operation of components is bypassed from the preprogrammed weekly test, presence of power downstream of all disconnects shall be verified weekly by a listed control unit.

2. Testing of all components bypassed from the preprogrammed weekly test
shall be in accordance with the Ghana Fire Code.

29.6.12.2 Wiring.
In addition to meeting the requirements of Ghana Wiring Code, all wiring, regardless of voltage, shall be fully enclosed within continuous raceways.

29.6.12.3 Activation.
Smoke control systems shall be activated in accordance with the Ghana Building Code or the Ghana Fire Code.

29.6.12.4 Automatic control.
Where complete automatic control is required or used, the automatic control sequences shall be initiated from an appropriately zoned automatic sprinkler system complying with the Ghana Fire Code, from manual controls provided with ready access for the fire department, and any smoke detectors required by engineering analysis.

29.6.12.13 Control-air tubing.
Control-air tubing shall be of sufficient size to meet the required response times. Tubing shall be flushed clean and dry prior to final connections. Tubing shall be adequately supported and protected from damage. Tubing passing through concrete or masonry shall be sleeved and protected from abrasion and electrolytic action.

Control-air tubing shall be hard-drawn copper, Type L, ACR in accordance with ASTM B42, ASTM B43, ASTM B68, ASTM B88, ASTM B251 and ASTM B280. Fittings shall be wrought copper or copper alloy, solder type in accordance with ASME B16.18 or ASME B16.22. Changes in direction shall be made with appropriate tool bends. Copper alloy compression-type fittings shall be used at final connection to devices; other joints shall be brazed using a BCuP5 brazing alloy with solidus above 1,100°F (593°C) and liquids below 1,500°F (816°C). Brazing flux shall be used on copper-to-copper alloy joints only.

Exception: Nonmetallic tubing used within control panels and at the final connection to devices provided that all of the following conditions are met:

1. Tubing shall comply with the requirements of this Code.
2. Tubing and connected device shall be completely enclosed within a galvanized or paint-grade steel enclosure having a minimum thickness of 0.7534 mm (0.0296 inch) (No. 22 gage). Entry to the enclosure shall be by copper tubing with a protective grommet of Neoprene or Teflon or by suitable brass compression to male barbed adapter.
3. Tubing shall be identified by appropriately documented coding.
4. Tubing shall be neatly tied and supported within the enclosure. Tubing bridging cabinets and doors or movable devices shall be of sufficient length to avoid tension and excessive stress. Tubing shall be protected against abrasion. Tubing connected to devices on doors shall be fastened along hinges.

29.6.12.13.2 Isolation from other functions.
Control tubing serving other than smoke control functions shall be isolated by automatic isolation valves or shall be an independent system.

29.6.12.13.3 Testing.
Control-air tubing shall be tested at three times the operating pressure for not less than 30 minutes without any noticeable loss in gauge pressure prior to final connection to devices.

The detection and control systems shall be clearly marked at all junctions, accesses and terminations.

29.6.12.15 Control diagrams.
Identical control diagrams shall be provided and maintained as required by the Ghana Fire Code.

29.6.12.16 Fire fighter’s smoke control panel.
A fire fighter’s smoke control panel for fire department emergency response purposes only shall be provided in accordance with the Ghana Fire Code.
29.6.12.17 System response time.
Smoke control system activation shall comply with the Ghana Fire Code.

29.6.12.18 Acceptance testing.
Devices, equipment, components and sequences shall be tested in accordance with the Ghana Fire Code.

29.6.12.19 System acceptance.
Acceptance of the smoke control system shall be in accordance with the Ghana Fire Code.

29.6.13 ENERGY RECOVERY VENTILATION SYSTEMS

29.6.13.1 General.
Energy recovery ventilation systems shall be installed in accordance with this clause. Where required for purposes of energy conservation, energy recovery ventilation systems shall comply with the International Energy Conservation Code. Ducted heat recovery ventilators shall be listed and labeled in accordance with this Code. Nonducted heat recovery ventilators shall be listed and labeled in accordance with this Code.

29.6.13.2 Prohibited applications.
Energy recovery ventilation systems shall not be used in the following systems:

2. Dust, stock and refuse systems that convey explosive or flammable vapours, fumes or dust.
4. Commercial kitchen exhaust systems serving Type I or Type II hoods.
5. Clothes dryer exhaust systems covered in this Code.

Exception: The application of ERV equipment that recovers sensible heat only utilizing coil-type heat exchangers shall not be limited by this clause.

A means of access shall be provided to the heat exchanger and other components of the system as required for service, maintenance, repair or replacement.

29.6.14.4 Recirculated air.
Air conveyed within energy recovery systems shall not be considered as recirculated air where the energy recovery ventilation system is constructed to limit cross-leakage between air streams to less than 10 percent of the total airflow design capacity.

29.7 BOILERS, WATER HEATERS AND PRESSURE VESSELS

This clause addresses boilers, water heaters, expansion tanks and pressure vessels in general, such as compressed air vessels. This part includes requirements for components of hydronic HVAC systems, with the focus being on safety, maintenance, testing and safety control devices.

29.7.1 GENERAL

29.7.1.1 Scope.
This part shall govern the installation, alteration and repair of boilers, water heaters and pressure vessels.

Exceptions:

1. Pressure vessels used for unheated water supply.
2. Containers for bulk oxygen and medical gas.
3. Unfired pressure vessels having a volume of 0.14 m$^3$ (5 cubic feet) or less operating at pressures not exceeding 250 pounds per square inch (psi) (1724 kPa) and located within occupancies of Groups B, F, H, M, R, S and U.
4. Pressure vessels used in refrigeration systems that are regulated by Part 8 of this Code.

29.7.2 WATER HEATERS

29.7.2.1 General.
Potable water heaters and hot water storage tanks shall be listed and labeled and installed in accordance with the manufacturer’s
instructions and this Code. Water heaters shall be capable of being removed without first removing a permanent portion of the building structure. The potable water connections and relief valves for all water heaters shall be installed to conform to plumbing practise. Domestic electric water heaters shall comply with this Code. Commercial electric water heaters shall comply with this Code. Oil-fired water heaters shall comply with UL 732. Solid-fuel-fired water heaters shall comply with this Code. Solar thermal water heating systems shall comply with Part 14 and ICC 900/SRCC 300.

29.7.2.2 Sizing.
Water heaters utilized for potable water heating application shall be sized appropriately from diminishing the required potable water-heating capacity.

29.7.2.3 Supplemental water-heating devices.
Potable water-heating devices that utilize refrigerant-to-water heat exchangers shall be approved and installed in accordance with manufacturer’s instructions.

29.7.3 PRESSURE VESSELS

29.7.3.1 General.
All pressure vessels, unless otherwise approved, shall be constructed, certified and installed in accordance with the manufacturer’s instructions and nationally recognized standards. Directly fired pressure vessels shall meet the requirements of Clause 11.4.

29.7.3.2 Piping.
All piping materials, fittings, joints, connections and devices associated with systems utilized in conjunction with pressure vessels shall be designed for the specific application and shall be approved.

29.7.3.3 Welding.
Welding on pressure vessels shall be performed by an R-Stamp holder in accordance with an approved standard.

29.7.4 BOILERS

29.7.4.1 Standards.
Boilers shall be designed, constructed and certified in accordance with this Code, Clause I or IV. Controls and safety devices for boilers with fuel input ratings of 12,500,000 Btu/hr (3,662,500 W) or less shall meet the requirements of this Code. Controls and safety devices for boilers with inputs greater than 12,500,000 Btu/hr (3,662,500 W) shall meet the requirements of the Ghana Fire Code. Packaged oil-fired boilers shall be listed and labeled in accordance with this Code. Packaged electric boilers shall be listed and labeled in accordance with this Code. Solid-fuel-fired boilers shall be listed and labeled in accordance with this Code.

29.7.4.2 Installation.
In addition to the requirements of this Code, the installation of boilers shall conform to the manufacturer’s instructions. Operating instructions of a permanent type shall be attached to the boiler. Boilers shall have all controls set, adjusted and tested by the installer. The manufacturer’s rating data and the nameplate shall be attached to the boiler.

29.7.4.3 Working clearance.
Clearances shall be maintained around boilers, generators, heaters, tanks and related equipment and appliances so as to permit inspection, servicing, repair, replacement and visibility of all gauges. Where boilers are installed or replaced, clearance shall be provided to allow access for inspection, maintenance and repair. Passageways around all sides of boilers shall have an unobstructed width of not less than 457 mm (18 inches), unless otherwise approved.

29.7.4.3.1 Top clearance.
Clearances from the tops of boilers to the ceiling or other overhead obstruction shall be in accordance with Table 29.7.4.3.1.

<table>
<thead>
<tr>
<th>BOILER TYPE</th>
<th>MINIMUM CLEARANCES FROM TOP OF BOILER TO CEILING OR OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1131
### OVERHEAD OBSTRUCTION (feet)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All boilers with manholes on top of the boiler except where a greater clearance is required in this table.</td>
<td>3</td>
</tr>
<tr>
<td>All boilers without manholes on top of the boiler except high-pressure steam boilers and where a greater clearance is required in this table.</td>
<td>2</td>
</tr>
<tr>
<td>High-pressure steam boilers with steam generating capacity not exceeding 5,000 pounds per hour.</td>
<td>3</td>
</tr>
<tr>
<td>High-pressure steam boilers with steam generating capacity exceeding 5,000 pounds per hour.</td>
<td>7</td>
</tr>
<tr>
<td>High-pressure steam boilers having heating surface not exceeding 1,000 square feet.</td>
<td>3</td>
</tr>
<tr>
<td>High-pressure steam boilers having heating surface in excess of 1,000 square feet.</td>
<td>7</td>
</tr>
<tr>
<td>High-pressure steam boilers with input not exceeding 5,000,000 Btu/h.</td>
<td>3</td>
</tr>
<tr>
<td>High-pressure steam boilers with input in excess of 5,000,000 Btu/h.</td>
<td>7</td>
</tr>
<tr>
<td>Steam-heating boilers and hot water-heating boilers with input exceeding 5,000,000 Btu/h.</td>
<td>3</td>
</tr>
<tr>
<td>Steam-heating boilers exceeding 5,000 pounds of steam per hour.</td>
<td>3</td>
</tr>
<tr>
<td>Steam-heating boilers and hot water-heating boilers having heating surface exceeding 1,000 square feet.</td>
<td>3</td>
</tr>
</tbody>
</table>

For SI: 1 foot = 304.8 mm, 1 square foot = \(0.0929 \text{ m}^2\), 1 pound per hour = 0.4536 kg/h, 1 Btu/hr = 0.293 W.

### 29.7.4.4 Mounting.

Equipment shall be set or mounted on a level base capable of supporting and distributing the weight contained thereon. Boilers, tanks and equipment shall be secured in accordance with the manufacturer’s installation instructions.

#### 29.7.4.5 Floors.

Boilers shall be mounted on floors of noncombustible construction, unless listed for mounting on combustible flooring.

#### 29.7.4.6 Boiler rooms and enclosures.

Boiler rooms and enclosures and access thereto shall comply with the Ghana Building Code. Boiler rooms shall be equipped with a floor drain or other approved means for disposing of liquid waste.

#### 29.7.4.7 Operating adjustments and instructions.

Hot water and steam boilers shall have all operating and safety controls set and operationally tested by the installing contractor. A complete control diagram and boiler operating instructions shall be furnished by the installer for each installation.

### 29.7.5 BOILER CONNECTIONS

#### 29.7.5.1 Valves.

Every boiler or modular boiler shall have a shutoff valve in the supply and return piping. For multiple boiler or multiple modular boiler installations, each boiler or modular boiler shall have individual shutoff valves in the supply and return piping.

**Exception:** Shutoff valves are not required in a system having a single low-pressure steam boiler.

#### 29.7.5.2 Potable water supply.

The water supply to all boilers shall be connected in accordance with the GWSC Rules.

### 29.7.6 SAFETY AND PRESSURE RELIEF VALVES AND CONTROLS

#### 29.7.6.1 Safety valves for steam boilers.

Steam boilers shall be protected with a safety valve.

#### 29.7.6.2 Safety relief valves for hot water boilers.

Hot water boilers shall be protected with a safety relief valve.

#### 29.7.6.3 Pressure relief for pressure vessels.

Pressure vessels shall be protected with a...
pressure relief valve or pressure-limiting device as required by the manufacturer’s installation instructions for the pressure vessel.

29.7.6.4 Approval of safety and safety relief valves.

Safety and safety relief valves shall be listed and labeled, and shall have a minimum rated capacity for the equipment or appliances served. Safety and safety relief valves shall be set at not greater than the nameplate pressure rating of the boiler or pressure vessel.

29.7.6.5 Installation.

Safety or relief valves shall be installed directly into the safety or relief valve opening on the boiler or pressure vessel. Valves shall not be located on either side of a safety or relief valve connection. The relief valve shall discharge by gravity.

29.7.6.6 Safety and relief valve discharge.

Safety and relief valve discharge pipes shall be of rigid pipe that is approved for the temperature of the system. High-pressure-steam safety valves shall be vented to the outside of the structure. The discharge piping serving pressure relief valves, temperature relief valves and combinations of such valves shall:

1. Not be directly connected to the drainage system.
2. Discharge through an air break located in the same room as the appliance.
3. Not be smaller than the diameter of the outlet of the valve served and shall discharge full size to the air break.
4. Serve a single relief device and shall not connect to piping serving any other relief device or equipment.
5. Discharge to the floor, to the pan serving the boiler or storage tank, to a waste receptor or to the outdoors.
6. Discharge in a manner that does not cause personal injury or structural damage.
7. Discharge to a termination point that is readily observable by the building occupants.
8. Not be trapped.
9. Be installed so as to flow by gravity.
10. Not terminate more than 152 mm (6 inches) above the floor or waste receptor.
11. Not have a threaded connection at the end of such piping.
12. Not have valves or tee fittings.
13. Be constructed of those materials tested, rated and approved for such use in accordance with this Code.

29.7.6.7 Boiler safety devices.

Boilers shall be equipped with controls and limit devices as required by the manufacturer’s installation instructions and the conditions of the listing.

29.7.6.8 Electrical requirements.

The power supply to the electrical control system shall be from a two-wire branch circuit that has a grounded conductor, or from an isolation transformer with a two-wire secondary. Where an isolation transformer is provided, one conductor of the secondary winding shall be grounded. Control voltage shall not exceed 150 volts nominal, line to line. Control and limit devices shall interrupt the ungrounded side of the circuit. A means of manually disconnecting the control circuit shall be provided and controls shall be arranged so that when deenergized, the burner shall be inoperative. Such disconnecting means shall be capable of being locked in the off position and shall be provided with ready access.

29.7.7 BOILER LOW-WATER CUTOFF

29.7.7.1 General.

Steam and hot water boilers shall be protected with a low-water cutoff control.

Exception: A low-water cutoff is not required for coil-type and water-tube-type boilers that require forced circulation of water through the boiler and that are protected with a flow sensing control.

29.7.7.2 Operation.

Low-water cutoff controls and flow sensing controls required by Clause 29.7.7.1 shall automatically stop the combustion operation of the appliance when the water level drops below the lowest safe water level as
established by the manufacturer or when water circulation stops, respectively.

29.7.8 BOTTOM BLOWOFF VALVE

29.7.8.1 General.

Steam boilers shall be equipped with bottom blowoff valve(s). The valve(s) shall be installed in the opening provided on the boiler. The minimum size of the valve(s) and associated piping shall be the size specified by the boiler manufacturer or the size of the boiler blowoff-valve opening. Where the maximum allowable working pressure of the boiler exceeds 100 psig (689 kPa), two bottom blowoff valves shall be provided consisting of either two slow-opening valves in series or one quick-opening valve and one slow-opening valve in series, with the quick-opening valve installed closest to the boiler.

29.7.8.2 Discharge.

Blowoff valves shall discharge to a safe place of disposal. Where discharging to the drainage system, the installation shall conform to the International Plumbing Code.

29.7.9 HOT WATER BOILER EXPANSION TANK

29.7.9.1 Where required.

An expansion tank shall be installed in every hot water system. For multiple boiler installations, not less than one expansion tank is required. Expansion tanks shall be of the closed or open type. Tanks shall be rated for the pressure of the hot water system.

Exception: Expansion tanks shall not be required in the collector loop of drain-back systems.

29.7.9.2 Closed type expansion tanks

Closed-type expansion tanks shall be installed in accordance with the manufacturer’s instructions. Expansion tanks for systems designed to have an operating pressure in excess of 30 psi (207 kPa) shall be constructed and certified in accordance with this Code. The size of the tank shall be based on the capacity of the hot-water-heating system. The minimum size of the tank shall be determined in accordance with the following equation where all necessary information is known:

\[ V_t = \frac{(P_a - P_f)}{(P_a - P_o)} V_s \]  

For SI:

\[ V_t = \frac{(0.000738T - 0.03348)}{(P_a - P_f)} V_s \]

where:

- \( V_t \) = Minimum volume of tanks (gallons) (L).
- \( V_s \) = Volume of system, not including expansion tanks (gallons) (L).
- \( T \) = Average operating temperature (°F) (°C).
- \( P_a \) = Atmospheric pressure (psi) (kPa).
- \( P_f \) = Fill pressure (psi) (kPa).
- \( P_o \) = Maximum operating pressure (psi) (kPa).

Where all necessary information is not known, the minimum size of the tank shall be determined from Table 29.7.9.2.

### TABLE 29.7.9.2
CLOSED-TYPE EXPANSION TANK SIZING

<table>
<thead>
<tr>
<th>SYSTEM VOLUME IN GALLONS</th>
<th>TANK CAPACITIES IN GALLONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pressurized Diaphragm Type</td>
</tr>
<tr>
<td>100</td>
<td>9</td>
</tr>
<tr>
<td>200</td>
<td>17</td>
</tr>
<tr>
<td>300</td>
<td>25</td>
</tr>
<tr>
<td>400</td>
<td>33</td>
</tr>
<tr>
<td>500</td>
<td>42</td>
</tr>
<tr>
<td>1,000</td>
<td>83</td>
</tr>
<tr>
<td>2,000</td>
<td>165</td>
</tr>
</tbody>
</table>

For SI: 1 gallon = 3.795 L.

29.7.9.3 Open-type expansion tanks.

Open-type expansion tanks shall be located not less than 1219 mm (4 feet) above the highest heating element. The tank shall be adequately sized for the hot water system. An overflow with a minimum diameter of 25 mm (1 inch) shall be installed at the top of the tank.
The overflow shall discharge to the drainage system in accordance with the Ghana Building Code.

29.7.10 GAUGES

29.7.10.1 Hot water boiler gauges.
Every hot water boiler shall have a pressure gauge and a temperature gauge, or a combination pressure and temperature gauge. The gauges shall indicate the temperature and pressure within the normal range of the system’s operation.

29.7.10.2 Steam boiler gauges.
Every steam boiler shall have a water-gauge glass and a pressure gauge. The pressure gauge shall indicate the pressure within the normal range of the system’s operation.

29.7.10.2.1 Water-gauge glass.
The gauge glass shall be installed so that the midpoint is at the normal boiler water level.

29.7.11 TESTS
29.7.11.1 Tests.
Upon completion of the assembly and installation of boilers and pressure vessels, acceptance tests shall be conducted in accordance with the requirements of this Code or the manufacturer's requirements, and such tests shall be approved. A copy of all test documents along with all manufacturer’s data reports required by this Code shall be submitted to the Code official.

29.7.11.2 Test gauges.
An indicating test gauge shall be connected directly to the boiler or pressure vessel where it is visible to the operator throughout the duration of the test. The pressure gauge scale shall be graduated over a range of not less than one and one-half times and not greater than four times the maximum test pressure. Gauges utilized for testing shall be calibrated and certified by the test operator.

29.8 REFRIGERATION

User note:
This clause provides for the protection of life and property from the potential fire and health hazards associated with refrigerant chemicals and the machinery that contains such chemicals. Some refrigerants are toxic, some are flammable and some are both. This part refers to the Ghana Fire Code®, ASHRAE 15 and IIAR standards 2 through 5.

29.8.1 GENERAL

29.8.1.1 Scope.
This part shall govern the design, installation, construction and repair of refrigeration systems that vapourize and liquefy a fluid during the refrigerating cycle. Refrigerant piping design and installation, including pressure vessels and pressure relief devices, shall conform to this Code. Permanently installed refrigerant storage systems and other components shall be considered as part of the refrigeration system to which they are attached.

29.8.1.2 Factory-built equipment and appliances.
Listed and labeled self-contained, factory-built equipment and appliances shall be tested in accordance with this Code. Such equipment and appliances are deemed to meet the design, manufacture and factory test requirements of this Code if installed in accordance with their listing and the manufacturer’s instructions.

29.8.1.3 Protection.
Any portion of a refrigeration system that is subject to physical damage shall be protected in an approved manner.

29.8.1.4 Water connection.
Water supply and discharge connections associated with refrigeration systems shall be made in accordance with this Code and the International Plumbing Code.

29.8.1.5 Fuel gas connection.
Fuel gas devices, equipment and appliances used with refrigeration systems shall be installed in accordance with this Code.

29.8.1.6 General.
Refrigeration systems shall comply with the requirements of this Code and, except as modified by this Code. Ammonia-refrigerating systems shall comply with this Code and, except as modified by this Code.

29.8.1.7 Maintenance.
Mechanical refrigeration systems shall be maintained in proper operating condition, free from accumulations of oil, dirt, waste, excessive corrosion, other debris and leaks.
29.8.1.8 Change in refrigerant type.
The type of refrigerant in refrigeration systems having a refrigerant circuit containing more than 220 pounds (99.8 kg) of Group A1 or 30 pounds (13.6 kg) of any other group refrigerant shall not be changed without prior notification to the Code official and compliance with the applicable Code provisions for the new refrigerant type.

29.8.1.9 Refrigerant discharge.
Notification of refrigerant discharge shall be provided in accordance with the Ghana Fire Code.

29.8.1.10 Locking access port caps.
Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps or shall be otherwise secured to prevent unauthorized access.

Exception: This clause shall not apply to refrigerant circuit access ports on equipment installed in controlled areas such as on roofs with locked access hatches or doors.

29.8.2 SYSTEM REQUIREMENTS

29.8.2.1 General.
The system classification, allowable refrigerants, maximum quantity, enclosure requirements, location limitations, and field pressure test requirements shall be determined as follows:

1. Determine the refrigeration system’s classification, in accordance with Clause 29.8.3.3.

2. Determine the refrigerant classification in accordance with Clause 29.8.3.1.

3. Determine the maximum allowable quantity of refrigerant in accordance with Clause 29.8.4, based on type of refrigerant, system classification and occupancy.

4. Determine the system enclosure requirements in accordance with Clause 29.8.4.

5. Refrigeration equipment and appliance location and installation shall be subject to the limitations of this Code.

6. Nonfactory-tested, field-erected equipment and appliances shall be pressure tested in accordance with this Code.

29.8.2.2 Refrigerants.
The refrigerant shall be that which the equipment or appliance was designed to utilize or converted to utilize.

29.8.2.2.1 Mixing.
Refrigerants, including refrigerant blends, with different designations in this Code shall not be mixed in a system.

Exception: Addition of a second refrigerant is allowed where permitted by the equipment or appliance manufacturer to improve oil return at low temperatures. The refrigerant and amount added shall be in accordance with the manufacturer’s instructions.

29.8.2.2.2 Purity.
Refrigerants used in refrigeration systems shall be new, recovered or reclaimed refrigerants in accordance with Clause 29.8.2.2.2.1, 29.8.2.2.2.2 or 29.8.2.2.2.3. Where required by the equipment or appliance owner or the Code official, the installer shall furnish a signed declaration that the refrigerant used meets the requirements of Clause 29.8.2.2.2.1, 29.8.2.2.2.2 or 29.8.2.2.2.3.

Exception: The refrigerant used shall meet the purity specifications set by the manufacturer of the equipment or appliance in which such refrigerant is used where such specifications are different from that specified in Clauses 29.8.2.2.2.1, 29.8.2.2.2.2 and 29.8.2.2.2.3.

29.8.2.2.2.1 New refrigerants.
Refrigerants shall be of a purity level specified by the equipment or appliance manufacturer.

29.8.2.2.2 Recovered refrigerants.
Refrigerants that are recovered from refrigeration and air-conditioning systems shall not be reused in other than the system from which they were recovered and in other systems of the same owner. Recovered refrigerants shall be filtered and dried before reuse. Recovered refrigerants that show clear signs of contamination shall not be reused unless reclaimed in accordance with Clause 29.8.2.2.2.3.
29.8.2.2.3 Reclaimed refrigerants.
Used refrigerants shall not be reused in a different owner’s equipment or appliances unless tested and found to meet the purity requirements of this Code. Contaminated refrigerants shall not be used unless reclaimed and found to meet the purity requirements of this Code.

29.8.2.3 Access port protection.
Refrigerant access ports shall be protected in accordance with Clause 29.8.1.10 whenever refrigerant is added to or recovered from refrigeration or air-conditioning systems.

29.8.3 REFRIGERATION SYSTEM CLASSIFICATION

29.8.3.1 Refrigerant classification.
Refrigerants shall be classified in accordance with this Code as listed in Table 29.8.3.1.
<table>
<thead>
<tr>
<th>CHEMICAL REFRIGERANT</th>
<th>FORMULA</th>
<th>CHEMICAL NAME OF BLEND</th>
<th>REFRIGERANT CLASSIFICATION</th>
<th>AMOUNT OF REFRIGERANT PER OCCUPIED SPACE</th>
<th>[F] DEGREES OF HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-11</td>
<td>CCl(<em>3) (</em>\text{F}) (<em>2) (</em>\text{F}) (_3)</td>
<td>trichlorofluoromethane</td>
<td>A1</td>
<td>0.39 1,100 6.2 C1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-12</td>
<td>CCl(<em>2) (</em>\text{F}) (<em>2) (</em>\text{F}) (_3)</td>
<td>dichlorodifluoromethane</td>
<td>A1</td>
<td>5.6 18,000 90 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-13</td>
<td>CCl(<em>2) (</em>\text{F}) (_3)</td>
<td>chlorotrifluoromethane</td>
<td>A1</td>
<td>— — — 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-13B</td>
<td>CBr(<em>3) (</em>\text{F}) (<em>2) (</em>\text{F}) (_3)</td>
<td>bromotrifluoromethane</td>
<td>A1</td>
<td>— — — 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-14</td>
<td>CF(<em>4) (</em>\text{F})</td>
<td>tetrafluoromethane (carbon tetrafluoride)</td>
<td>A1</td>
<td>25 110,000 400 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-22</td>
<td>CHCIF(<em>2) (</em>\text{F})</td>
<td>chlorodifluoromethane</td>
<td>A1</td>
<td>13 59,000 210 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-23</td>
<td>CHF(<em>3) (</em>\text{F})</td>
<td>trifluoromethane (fluoroform)</td>
<td>A1</td>
<td>7.3 41,000 120 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-30</td>
<td>CH(_2) Cl (<em>2) (</em>\text{F})</td>
<td>dichloromethane (methylene chloride)</td>
<td>B1</td>
<td>— — — —</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-32</td>
<td>CH(<em>3) (</em>\text{F}) (<em>2) (</em>\text{F})</td>
<td>difluoromethane (methylene fluoride)</td>
<td>A2</td>
<td>4.8 36,000 77 1,000</td>
<td>1-4-0</td>
</tr>
<tr>
<td>R-40</td>
<td>CH(_2) Cl (<em>3) (</em>\text{F})</td>
<td>chloromethane (methyl chloride)</td>
<td>B2</td>
<td>— — — —</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-50</td>
<td>CH(<em>3) (</em>\text{F})</td>
<td>methanol</td>
<td>A3</td>
<td>— — — 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-113</td>
<td>CCl(_2) FCCIF</td>
<td>1,1,2-trichloro-1,2,2-trifluorocarbon</td>
<td>A1</td>
<td>1.2 2,600 20 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-114</td>
<td>CCl(_2) CIF (_2)</td>
<td>1,2-dichloro-1,1,2,2-tetrafluoroethane</td>
<td>A1</td>
<td>8.7 20,000 140 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-115</td>
<td>CCIF CF (<em>2) (</em>\text{F})</td>
<td>chloropentafluoroethylene</td>
<td>A1</td>
<td>47 120,000 760 1,000</td>
<td>1-0-0</td>
</tr>
<tr>
<td>R-116</td>
<td>CF CF (<em>3) (</em>\text{F})</td>
<td>hexafluoroethane</td>
<td>A1</td>
<td>34 97,000 550 1,000</td>
<td>1-0-0</td>
</tr>
<tr>
<td>R-12</td>
<td>CHCl CF (<em>2) (</em>\text{F})</td>
<td>2,2-dichloro-1,1,1-trifluoroethane</td>
<td>B1</td>
<td>3.5 9,100 57 50</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-125</td>
<td>CHCICCF (<em>2) (</em>\text{F})</td>
<td>2-chloro-1,1,2,2-tetrafluoroethane</td>
<td>A1</td>
<td>3.5 10,000 56 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-126</td>
<td>CHF CF (<em>2) (</em>\text{F})</td>
<td>pentafluoroethane</td>
<td>A1</td>
<td>23 75,000 370 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-13</td>
<td>CH CF CF (<em>2) (</em>\text{F})</td>
<td>1,1,1,2-tetrafluoroethene</td>
<td>A1</td>
<td>13 50,000 210 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-14</td>
<td>CH(_2) CCI (<em>3) (</em>\text{F})</td>
<td>1,1-dichloro-1-fluoroethene</td>
<td>—</td>
<td>0.78 2,600 12 500</td>
<td>2-1-0</td>
</tr>
<tr>
<td>R-14B</td>
<td>CH(_2) CCl (<em>2) (</em>\text{F})</td>
<td>1-chloro-1,1-difluoroethene</td>
<td>A2</td>
<td>5.1 20,000 83 1,000</td>
<td>2-4-0</td>
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<tr>
<td>R-14C</td>
<td>CH CF (<em>2) (</em>\text{F})</td>
<td>1,1,1-trifluoroethane</td>
<td>A2</td>
<td>4.5 21,000 70 1,000</td>
<td>2-0-0</td>
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<tr>
<td>R-15</td>
<td>CH CF CH (<em>3) (</em>\text{F})</td>
<td>1,1-difluoroethene</td>
<td>A2</td>
<td>2.0 12,000 32 1,000</td>
<td>1-4-0</td>
</tr>
<tr>
<td>R-17</td>
<td>CH(<em>3) (</em>\text{F}) (_3)</td>
<td>ethane</td>
<td>A3</td>
<td>0.54 7,000 8.7 1,000</td>
<td>2-4-0</td>
</tr>
<tr>
<td>R-17E</td>
<td>CH(_2) OCH (<em>3) (</em>\text{F})</td>
<td>Methoxymethane (dimethyl ether)</td>
<td>A3</td>
<td>1.0 8,500 16 1,000</td>
<td>—</td>
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<tr>
<td>R-21</td>
<td>CF CF CF CF (<em>2) (</em>\text{F})</td>
<td>octafluoropropene</td>
<td>A1</td>
<td>43 90,000 690 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-21B</td>
<td>CF CHCF (<em>2) (</em>\text{F})</td>
<td>1,1,1,2,3,3,3-heptafluoropropane</td>
<td>A1</td>
<td>36 84,000 580 1,000</td>
<td>—</td>
</tr>
<tr>
<td>R-23</td>
<td>CF CH CF (<em>3) (</em>\text{F}) (<em>2) (</em>\text{F})</td>
<td>1,1,1,3,3,3-hexafluoropropane</td>
<td>A1</td>
<td>21 55,000 340 1,000</td>
<td>2-0-0</td>
</tr>
</tbody>
</table>
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R-245fa
R-290

R-C318
R-400

d

CHEMICAL
REFRIGERANT

GS 1207: 2018

CHF CH CF
2 2 3
CH CH CH
3 2 3
-(CF ) 24

1,1,1,3,3pentafluoropropane

B1

12

34,000

190

300

2-0-0

propane

A3

0.56

5,300

9.5

1,000

2-4-0

octafluorocyclobutane

A1

41

80,000

660

1,000

—

zeotrope

R-12/114 (50.0/50.0)

A1

10

28,000

160

1,000

2-0-0

b

b

TABLE 29.8.3.1—continued
REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

FORMULA

d
R-400

zeotrope

R-401A

zeotrope

R-401B

zeotrope

R-401C

zeotrope

R-402A

zeotrope

R-402B

zeotrope

R-403A

zeotrope

R-403B

zeotrope

R-404A

zeotrope

R-405A

zeotrope

R-406A

zeotrope

R-407A

zeotrope

R-407B

zeotrope

R-407C

zeotrope

R-407D

zeotrope

R-407E

zeotrope

R-407F

zeotrope

CHEMICAL NAME
OF BLEND

R-12/114
(60.0/40.0)
R-22/152a/124
(53.0/13.0/34.0)
R-22/152a/124
(61.0/11.0/28.0)
R-22/152a/124
(33.0/15.0/52.0)
R-125/290/22
(60.0/2.0/38.0)
R-125/290/22
(38.0/2.0/60.0)
R-290/22/218
(5.0/75.0/20.0)
R-290/22/218
(5.0/56.0/39.0)
R-125/143a/134a
(44.0/52.0/4.0)
R22/152a/142b/C318
(45.0/7.0/5.5/2.5)
R-22/600a/142b
(55.0/4.0/41.0)
R-32/125/134a
(20.0/40.0/40.0)
R-32/125/134a
(10.0/70.0/20.0)
R-32/125/134a
(23.0/25.0/52.0)
R-32/125/134a
(15.0/15.0/70.0)
R-32/125/134a
(25.0/15.0/60.0)
R-32/125/134a
(30.0/30.0/40.0)

REFRIGERANT
CLASSIFICATION

AMOUNT OF REFRIGERANT
PER OCCUPIED SPACE
Pounds
per
3
e
1,000
ppm
g/m
OEL
cubic
feet

[F]
DEGREES
OF
a
HAZARD

A1

11

30,000

170

1,000

A1

6.6

27,000

110

1,000

b
2-0-0

A1

7.2

30,000

120

1,000

b
2-0-0

A1

5.2

20,000

84

1,000

b
2-0-0

A1

17

66,000

270

1,000

b
2-0-0

A1

15

63,000

240

1,000

b
2-0-0

A2

7.6

33,000

120

1,000

b
2-0-0

A1

18

70,000

290

1,000

b
2-0-0

A1

31

130,000

500

1,000

b
2-0-0

—

16

57,000

260

1,000

—

A2

4.7

21,000

25

1,000

—

A1

19

83,000

300

1,000

b
2-0-0

A1

21

79,000

330

1,000

b
2-0-0

A1

18

81,000

290

1,000

b
2-0-0

A1

16

68,000

250

1,000

b
2-0-0

A1

17

80,000

280

1,000

b
2-0-0

A1

20

95,000

320

1,000

—

1139


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<tr>
<th>Code</th>
<th>Zeotrope</th>
<th>Composition</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<tbody>
<tr>
<td>R-408A</td>
<td>zeotrope</td>
<td>R-125/143a/22 (7.0/46.0/47.0)</td>
<td>A1</td>
<td>21</td>
<td>95,000</td>
<td>340</td>
<td>1,000</td>
<td>2-0-0</td>
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<tr>
<td>R-409A</td>
<td>zeotrope</td>
<td>R-22/124/142b (60.0/25.0/15.0)</td>
<td>A1</td>
<td>7.1</td>
<td>29,000</td>
<td>110</td>
<td>1,000</td>
<td>2-0-0</td>
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<tr>
<td>R-409B</td>
<td>zeotrope</td>
<td>R-22/124/142b (65.0/25.0/10.0)</td>
<td>A1</td>
<td>7.3</td>
<td>30,000</td>
<td>120</td>
<td>1,000</td>
<td>2-0-0</td>
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<td>R-410A</td>
<td>zeotrope</td>
<td>R-32/125 (50.0/50.0)</td>
<td>A1</td>
<td>26</td>
<td>140,000</td>
<td>420</td>
<td>1,000</td>
<td>2-0-0</td>
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<td>R-410B</td>
<td>zeotrope</td>
<td>R-32/125 (45.0/55.0)</td>
<td>A1</td>
<td>27</td>
<td>140,000</td>
<td>430</td>
<td>1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-411A</td>
<td>zeotrope</td>
<td>R-127/22/152a (1.5/87.5/11.0)</td>
<td>A2</td>
<td>2.9</td>
<td>14,000</td>
<td>46</td>
<td>990</td>
<td>—</td>
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<tr>
<td>R-411B</td>
<td>zeotrope</td>
<td>R-1270/22/152a (3.0/94.0/3.0)</td>
<td>A2</td>
<td>2.8</td>
<td>13,000</td>
<td>45</td>
<td>980</td>
<td>—</td>
</tr>
<tr>
<td>R-412A</td>
<td>zeotrope</td>
<td>R-22/218/142b (70.0/5.0/25.0)</td>
<td>A2</td>
<td>5.1</td>
<td>22,000</td>
<td>82</td>
<td>1,000</td>
<td>—</td>
</tr>
<tr>
<td>R-413A</td>
<td>zeotrope</td>
<td>R-218/134a/600a (9.0/88.0/3.0)</td>
<td>A2</td>
<td>5.8</td>
<td>22,000</td>
<td>94</td>
<td>1,000</td>
<td>—</td>
</tr>
<tr>
<td>R-414A</td>
<td>zeotrope</td>
<td>R-22/124/600a/142b (51.0/28.5/4.0/16.5)</td>
<td>A1</td>
<td>6.4</td>
<td>26,000</td>
<td>100</td>
<td>1,000</td>
<td>—</td>
</tr>
<tr>
<td>R-414B</td>
<td>zeotrope</td>
<td>R-22/124/600a/142b (50.0/39.0/1.5/9.5)</td>
<td>A1</td>
<td>6.0</td>
<td>23,000</td>
<td>95</td>
<td>1,000</td>
<td>—</td>
</tr>
<tr>
<td>R-415A</td>
<td>zeotrope</td>
<td>R-22/152a (82.0/18.0)</td>
<td>A2</td>
<td>2.9</td>
<td>14,000</td>
<td>47</td>
<td>1,000</td>
<td>—</td>
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<tr>
<td>R-415B</td>
<td>zeotrope</td>
<td>R-22/152a (25.0/75.0)</td>
<td>A2</td>
<td>2.1</td>
<td>12,000</td>
<td>34</td>
<td>1,000</td>
<td>—</td>
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<tr>
<td>R-416A</td>
<td>zeotrope</td>
<td>R-134a/124/600 (59.0/39.5/1.5)</td>
<td>A1</td>
<td>3.9</td>
<td>14,000</td>
<td>62</td>
<td>1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-417A</td>
<td>zeotrope</td>
<td>R-125/134a/600 (46.6/50.0/3.4)</td>
<td>A1</td>
<td>3.5</td>
<td>13,000</td>
<td>56</td>
<td>1,000</td>
<td>2-0-0</td>
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<td>R-417B</td>
<td>zeotrope</td>
<td>R-125/134a/600 (79.0/18.3/2.7)</td>
<td>A1</td>
<td>4.3</td>
<td>15,000</td>
<td>70</td>
<td>1,000</td>
<td>—</td>
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<tr>
<td>R-417C</td>
<td>zeotrope</td>
<td>R-125/134a/600 (19.5/78.8/1.7)</td>
<td>A1</td>
<td>5.4</td>
<td>21,000</td>
<td>87</td>
<td>1,000</td>
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(continued)
## TABLE 29.8.3.1—continued
### REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

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<thead>
<tr>
<th>CHEMICAL REFRIGERANT</th>
<th>FORMULA</th>
<th>CHEMICAL NAME OF BLEND</th>
<th>REFRIGERANT CLASSIFICATION</th>
<th>AMOUNT OF REFRIGERANT PER OCCUPIED SPACE</th>
<th>[F] DEGREES OF HAZARD&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pounds per 1,000 cubic feet</td>
<td>ppm</td>
</tr>
<tr>
<td>R-418A</td>
<td>zeotrope</td>
<td>R-290/22/152a (1.5/96.0/2.5)</td>
<td>A2</td>
<td>4.8</td>
<td>22,000</td>
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<td>R-419A</td>
<td>zeotrope</td>
<td>R-125/134a/E170 (77.0/19.0/4.0)</td>
<td>A2</td>
<td>4.2</td>
<td>15,000</td>
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<tr>
<td>R-419B</td>
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<td>R-125/134a/E170 (48.5/48.0/3.5)</td>
<td>A2</td>
<td>4.6</td>
<td>17,000</td>
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<td>R-420A</td>
<td>zeotrope</td>
<td>R-134a/142b (68.0/12.0)</td>
<td>A1</td>
<td>12</td>
<td>45,000</td>
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<td>R-421A</td>
<td>zeotrope</td>
<td>R-125/134a (58.0/42.0)</td>
<td>A1</td>
<td>17</td>
<td>61,000</td>
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<td>zeotrope</td>
<td>R-125/134a (85.0/15.0)</td>
<td>A1</td>
<td>21</td>
<td>69,000</td>
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<td>R-422A</td>
<td>zeotrope</td>
<td>R-125/134a/600a (85.1/15.0/3.4)</td>
<td>A1</td>
<td>18</td>
<td>63,000</td>
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<td>R-422B</td>
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<td>R-125/134a/600a (65.0/42.0/3.0)</td>
<td>A1</td>
<td>16</td>
<td>56,000</td>
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<td>R-125/134a/600a (62.0/15.0/3.0)</td>
<td>A1</td>
<td>18</td>
<td>62,000</td>
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<td>R-125/134a/600a (65.1/15.0/3.4)</td>
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<td>16</td>
<td>58,000</td>
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<td>R-125/134a/600a (58.0/39.0/2.7)</td>
<td>A1</td>
<td>16</td>
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<tr>
<td>R-432A</td>
<td>zeotrope</td>
<td>R-134a/227a (52.5/47.5)</td>
<td>A1</td>
<td>19</td>
<td>59,000</td>
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<td>R-432B</td>
<td>zeotrope</td>
<td>R-125/134a/600a/601a (50.5/47.0/9.1/0.0/0.6)</td>
<td>A1</td>
<td>6.2</td>
<td>23,000</td>
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<td>R-433A</td>
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<td>R-32/134a/227a (18.5/69.3/12.0)</td>
<td>A1</td>
<td>16</td>
<td>72,000</td>
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<td>R-125/134a/600a/601a (5.1/93.0/1.3/0.6)</td>
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<td>5.2</td>
<td>20,000</td>
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<td>zeotrope</td>
<td>R-32/125/143a/134a (15.0/25.0/10.0/50.0)</td>
<td>A1</td>
<td>18</td>
<td>79,000</td>
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<tr>
<td>R-434A</td>
<td>zeotrope</td>
<td>R-125/143a/290/600a (7.5/20.0/6.1/1.9)</td>
<td>A1</td>
<td>23</td>
<td>83,000</td>
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<tr>
<td>R-434B</td>
<td>zeotrope</td>
<td>R-E170/152a/600a (60.0/10.0/30.0)</td>
<td>A3</td>
<td>0.81</td>
<td>6,300</td>
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<td>R-434C</td>
<td>zeotrope</td>
<td>R-152a/600a (76.0/24.0)</td>
<td>A3</td>
<td>1.3</td>
<td>8,000</td>
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<td>R-435A</td>
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<td>R-290/152a (71.0/23.0)</td>
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<td>0.69</td>
<td>5,500</td>
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<td>R-435B</td>
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<td>R-1270/E170 (80.0/20.0)</td>
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<td>0.13</td>
<td>1,200</td>
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<td>R-1270/290 (30.0/70.0)</td>
<td>A3</td>
<td>0.34</td>
<td>3,100</td>
</tr>
<tr>
<td>R-436A</td>
<td>zeotrope</td>
<td>R-1270/290 (5.0/95.0)</td>
<td>A3</td>
<td>0.51</td>
<td>4,500</td>
</tr>
<tr>
<td>R-436B</td>
<td>zeotrope</td>
<td>R-1270/290 (25.0/75.0)</td>
<td>A3</td>
<td>0.41</td>
<td>3,600</td>
</tr>
<tr>
<td>R-438A</td>
<td>zeotrope</td>
<td>R-125/143a/600a (63.2/18.0/16.0/2.8)</td>
<td>A1</td>
<td>20</td>
<td>73,000</td>
</tr>
<tr>
<td>R-438B</td>
<td>zeotrope</td>
<td>R-E170/152a (80.0/20.0)</td>
<td>A3</td>
<td>1.1</td>
<td>8,500</td>
</tr>
<tr>
<td>R-439A</td>
<td>zeotrope</td>
<td>R-290/600a (56.0/44.0)</td>
<td>A3</td>
<td>0.50</td>
<td>4,000</td>
</tr>
<tr>
<td>R-439B</td>
<td>zeotrope</td>
<td>R-290/600a (52.0/48.0)</td>
<td>A3</td>
<td>0.51</td>
<td>4,000</td>
</tr>
<tr>
<td>R-441A</td>
<td>zeotrope</td>
<td>R-125/134a/600/601 (19.5/78.5/1.4/0.6)</td>
<td>A1</td>
<td>5.0</td>
<td>19,000</td>
</tr>
<tr>
<td>CHEMICAL REFRIERGANT</td>
<td>FORMULA</td>
<td>CHEMICAL NAME OF BLEND</td>
<td>REFRIGERANT CLASSIFICATION</td>
<td>AMOUNT OF REFRIGERANT PER OCCUPIED SPACE</td>
<td>[F] DEGREES OF HAZARD</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------</td>
<td>------------------------</td>
<td>--------------------------</td>
<td>------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pounds per 1,000 cubic feet</td>
<td>ppm</td>
</tr>
<tr>
<td>R-442A</td>
<td>zeotrope</td>
<td>R-1270/290/600a (55.0/40.0/5.0)</td>
<td>A3</td>
<td>0.19</td>
<td>1,700</td>
</tr>
<tr>
<td>R-443A</td>
<td>zeotrope</td>
<td>R-32/152a/1234ze(E) (12.0/5.0/83.0)</td>
<td>A2</td>
<td>5.1</td>
<td>21,000</td>
</tr>
<tr>
<td>R-444A</td>
<td>zeotrope</td>
<td>R-32/152a/1234ze(E) (41.5/10.0/48.5)</td>
<td>f A2</td>
<td>4.3</td>
<td>23,000</td>
</tr>
<tr>
<td>R-445A</td>
<td>zeotrope</td>
<td>R-744/134a/1234ze(E) (6.0/9.0/85.0)</td>
<td>f A2</td>
<td>4.2</td>
<td>16,000</td>
</tr>
<tr>
<td>R-446A</td>
<td>zeotrope</td>
<td>R-32/1234ze(E)/600 (68.0/29.0/3.0)</td>
<td>f A2</td>
<td>2.5</td>
<td>16,000</td>
</tr>
<tr>
<td>R-447A</td>
<td>zeotrope</td>
<td>R-32/125/1234ze(E) (68.0/3.5/28.5)</td>
<td>f A2</td>
<td>2.6</td>
<td>16,000</td>
</tr>
<tr>
<td>R-448A</td>
<td>zeotrope</td>
<td>R-32/125/1234yf/134a/1234ze(E) (26.0/26.0/20.0/21.0/7.0)</td>
<td>A1</td>
<td>24</td>
<td>110,000</td>
</tr>
<tr>
<td>R-449A</td>
<td>zeotrope</td>
<td>R-32/125/1234yf/134a (24.3/24.7/25.3/25.7)</td>
<td>A1</td>
<td>23</td>
<td>100,000</td>
</tr>
<tr>
<td>R-450A</td>
<td>zeotrope</td>
<td>R-134a/1234ze(E) (42.0/58.0)</td>
<td>A1</td>
<td>20</td>
<td>72,000</td>
</tr>
<tr>
<td>R-451A</td>
<td>zeotrope</td>
<td>R-1234yf/134a (89.8/10.2)</td>
<td>f A2</td>
<td>5.3</td>
<td>18,000</td>
</tr>
<tr>
<td>R-452A</td>
<td>zeotrope</td>
<td>R-1234yf/134a (88.8/11.2)</td>
<td>f A2</td>
<td>5.3</td>
<td>18,000</td>
</tr>
<tr>
<td>R-453A</td>
<td>zeotrope</td>
<td>R-32/125/1234yf (11.0/59.0/30.0)</td>
<td>A1</td>
<td>27</td>
<td>100,000</td>
</tr>
<tr>
<td>R-454A</td>
<td>zeotrope</td>
<td>R-12/152a (73.8/26.2)</td>
<td>A1</td>
<td>7.6</td>
<td>30,000</td>
</tr>
<tr>
<td>R-455A</td>
<td>zeotrope</td>
<td>R-22/12 (75.0/25.0)</td>
<td>A1</td>
<td>13</td>
<td>54,000</td>
</tr>
<tr>
<td>R-456A</td>
<td>zeotrope</td>
<td>R-22/115 (48.8/51.2)</td>
<td>A1</td>
<td>21</td>
<td>73,000</td>
</tr>
<tr>
<td>R-457A</td>
<td>zeotrope</td>
<td>R-23/13 (40.1/59.9)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>FORMULA</th>
<th>CHEMICAL NAME OF BLEND</th>
<th>REFRIGERANT CLASSIFICATION</th>
<th>AMOUNT OF REFRIGERANT PER OCCUPIED SPACE</th>
<th>[F] DEGREES OF HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-504</td>
<td>azeotrope</td>
<td>R-32/115 (48.2/51.8)</td>
<td>A3</td>
<td>0.87 7,300 14 1,000</td>
<td>-</td>
</tr>
<tr>
<td>R-514A</td>
<td>azeotrope</td>
<td>R-125/143a (50.0/50.0)</td>
<td>A1</td>
<td>1.0 130,000 520 1,000</td>
<td>2-0-0</td>
</tr>
<tr>
<td>R-515A</td>
<td>azeotrope</td>
<td>R-26/218 (44.0/56.0)</td>
<td>A1</td>
<td>1.3 4,000 9.6 1,000</td>
<td>2-0-0</td>
</tr>
</tbody>
</table>

(continued)
For SI: 1 pound = 0.454 kg, 1 cubic foot = 0.0283 m$^3$

a. Degrees of hazard are for health, fire, and reactivity, respectively, in accordance with NFPA 704.
b. Reduction to 1-0-0 is allowed if analysis satisfactory to the Code official shows that the maximum concentration for a rupture or full loss of refrigerant charge would not exceed the IDLH, considering both the refrigerant quantity and room volume.
c. For installations that are entirely outdoors, use 3-1-0.
d. Class I ozone depleting substance; prohibited for new installations.
e. Occupational Exposure Limit based on the OSHA PEL, ACGIH TLV-TWA, the TERA WEEL or consistent value on a time-weighed average (TWA) basis (unless noted C for ceiling) for an 8 hr/d and 40 hr/wk.
f. The ASHRAE Standard 34 flammability classification for this refrigerant is 2L, which is a subclass of Class 2.

29.8.3.2 Occupancy classification

Locations of refrigerating systems are described by occupancy classifications that consider the ability of people to respond to potential exposure to refrigerants. Where equipment or appliances, other than piping, are located outside a building and within 20 feet (6096 mm) of any building opening, such equipment or appliances shall be governed by the occupancy classification of the building. Occupancy classifications shall be defined as follows:

1. Institutional occupancy is that portion of premises from which occupants cannot readily leave without the assistance of others because they are disabled, debilitated or confined. Institutional occupancies include, among others, hospitals, nursing homes, asylums and spaces containing locked cells.

2. Public assembly occupancy is that portion of premises where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly occupancies include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants and theaters.

3. Residential occupancy is that portion of premises that provides the occupants with complete independent living facilities, including permanent provisions for living, sleeping, eating, cooking and sanitation. Residential occupancies include, among others, dormitories, hotels, multiunit apartments and private residences.

3. Commercial occupancy is that portion of premises where people transact business, receive personal service or purchase food and other goods. Commercial occupancies include, among others, office and professional buildings, markets (but not large mercantile occupancies) and work or storage areas that do not qualify as industrial occupancies.

5. Large mercantile occupancy is that portion of premises where more than 100 persons congregate on levels above or below street level to purchase personal merchandise.

6. Industrial occupancy is that portion of premises that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process or store goods such as chemicals, food, ice, meat or petroleum.

7. Mixed occupancy occurs where two or more occupancies are located within the same building. Where each occupancy is isolated from the rest of the building by tight walls, floors and ceilings and by self-closing doors, the requirements for each occupancy shall apply to its portion of the building. Where the various occupancies are not so isolated, the occupancy having the most stringent requirements shall be the governing occupancy.

29.8.3.3 System classification.

Refrigeration systems shall be classified according to the degree of probability that refrigerant leaked from a failed connection, seal or component could enter an occupied area. The distinction is based on the basic design or location of the components.

29.8.3.3.1 Low-probability systems.

Double-indirect open-spray systems, indirect closed systems and indirect-vented closed systems shall be classified as low-probability systems, provided that all refrigerant-containing piping and fittings are isolated.
where the quantities in Table 29.8.3.1 are exceeded.

29.8.3.2 High-probability systems.
Direct systems and indirect open-spray systems shall be classified as high-probability systems.

Exception: An indirect open-spray system shall not be required to be classified as a high-probability system if the pressure of the secondary coolant is at all times (operating and standby) greater than the pressure of the refrigerant.

29.8.4 SYSTEM APPLICATION REQUIREMENTS

29.8.4.1 General.
The refrigerant, occupancy and system classification cited in this clause shall be determined in accordance with Clauses 29.8.3.1, 29.8.3.2 and 29.8.3.3, respectively.

29.8.4.2 Machinery room.
Except as provided in Clauses 29.8.4.2.1 and 29.8.4.2.2, all components containing the refrigerant shall be located either outdoors or in a machinery room where the quantity of refrigerant in an independent circuit of a system exceeds the amounts shown in Table 29.8.3.1. For refrigerant blends not listed in Table 29.8.3.1, the same requirement shall apply where the amount for any blend component exceeds that indicated in Table 29.8.3.1 for that component. This requirement shall also apply where the combined amount of the blend components exceeds a limit of 69,100 parts per million (ppm) by volume. Machinery rooms required by this clause shall be constructed and maintained in accordance with Clause 29.8.5 for Group A1 and B1 refrigerants and in accordance with Clauses 29.8.5 and 29.8.6 for Group A2, B2, A3 and B3 refrigerants.

Exceptions:

1. Machinery rooms are not required for listed equipment and appliances containing not more than 3 kg (6.6 pounds) of refrigerant, regardless of the refrigerant's safety classification, where installed in accordance with the equipment's or appliance's listing and the equipment or appliance manufacturer's installation instructions.

2. Piping in conformance with this Code is allowed in other locations to connect components installed in a machinery room with those installed outdoors.

29.8.4.2.1 Institutional occupancies.
The amounts shown in this code shall be reduced by 50 percent for all areas of institutional occupancies except kitchens, laboratories and mortuaries. The total of all Group A2, B2, A3 and B3 refrigerants shall not exceed 250 kg (550 pounds) in occupied areas or machinery rooms.

29.8.4.2.2 Industrial occupancies and refrigerated rooms.
This clause applies only to rooms and spaces that: are within industrial occupancies; contain a refrigerant evaporator; are maintained at temperatures below 68°F (20°C); and are used for manufacturing, food and beverage preparation, meat cutting, other processes and storage. Where a machinery room would otherwise be required by this Code, a machinery room shall not be required where all of the following conditions are met:

1. The space containing the machinery is separated from other occupancies by tight construction with tight-fitting doors.

2. Access is restricted to authorized personnel.

3. Refrigerant detectors are installed as required for machinery rooms in accordance with Clause 29.8.5.3.

Exceptions:

1. Refrigerant detectors are not required in unoccupied areas that contain only continuous piping that does not include valves, valve assemblies, equipment, or equipment connections.

2. Where approved alternatives are provided, refrigerant detectors for ammonia refrigeration are not required for rooms or areas that are always occupied, and for rooms or areas that have high humidity or other harsh conditions.
environmental conditions that are incompatible with detection devices.

4. Surfaces having temperatures exceeding 800°F (427°C) and open flames are not present where any Group A2, B2, A3 or B3 refrigerant is used.

5. All electrical equipment and appliances conform to Class 1, Division 2, hazardous location classification requirements of NFPA 70 (Ghana Wiring Code) where the quantity of any Group A2, B2, A3 or B3 refrigerant, other than ammonia, in a single independent circuit would exceed 25 percent of the lower flammability limit (LFL) upon release to the space.

6. All refrigerant-containing parts in systems with a total connected compressor power exceeding 100 horsepower (hp) (74.6 kW)—except evaporators used for refrigeration or dehumidification, condensers used for heating, control and pressure relief valves for either, low-probability pumps and connecting piping—are located either outdoors or in a machinery room.

29.8.4.3 Refrigerant restrictions.
Refrigerant applications, maximum quantities and use shall be restricted in accordance with Clauses 29.8.4.3.1 through 29.8.4.3.4.

29.8.4.3.1 Air-conditioning for human comfort.
In other than industrial occupancies where the quantity in a single independent circuit does not exceed the amount in this Code, Group B1, B2 and B3 refrigerants shall not be used in high-probability systems for air-conditioning for human comfort.

29.8.4.3.2 Nonindustrial occupancies.
Group A2 and B2 refrigerants shall not be used in high-probability systems where the quantity of refrigerant in any independent refrigerant circuit exceeds the amount shown in this Code. Group A3 and B3 refrigerants shall not be used except where approved.

Exception: This clause does not apply to laboratories where the floor area per occupant is not less than 9.3 m² (100 square feet).

### TABLE 29.8.4.3.2
MAXIMUM PERMISSIBLE QUANTITIES OF REFRIGERANTS

<table>
<thead>
<tr>
<th>TYPE OF REFRIGERATION SYSTEM</th>
<th>MAXIMUM POUNDS FOR VARIOUS OCCUPANCIES</th>
<th>Institutional</th>
<th>Assembly</th>
<th>Residential</th>
<th>All other occupancies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealed absorption system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In exit access</td>
<td>0</td>
<td>0</td>
<td>3.3</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>In adjacent outdoor locations</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>In other than exit access</td>
<td>0</td>
<td>6.6</td>
<td>6.6</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>Unit systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In other than exit access</td>
<td>0</td>
<td>0</td>
<td>6.6</td>
<td>6.6</td>
<td></td>
</tr>
</tbody>
</table>

For SI: 1 pound = 0.454 kg.

29.8.4.3.3 All occupancies.
The total of all Group A2, B2, A3 and B3 refrigerants other than R-717, ammonia, shall not exceed 1,100 pounds (499 kg) except where approved.

29.8.4.3.4 Protection from refrigerant decomposition.
Where any device having an open flame or surface temperature greater than 800°F (427°C) is used in a room containing more than 6.6 pounds (3 kg) of refrigerant in a single independent circuit, a hood and exhaust
system shall be provided in accordance with Clause 29.6.9. Such exhaust system shall exhaust combustion products to the outdoors.

**Exception:** A hood and exhaust system shall not be required where any of the following apply:

1. The refrigerant is R-717, R-718 or R-744.
2. The combustion air is ducted from the outdoors in a manner that prevents leaked refrigerant from being combusted.
3. A refrigerant detector is used to stop the combustion in the event of a refrigerant leak (see Clauses 29.8.5.3 and 29.8.5.5).

### 29.8.4.4 Volume calculations

Volume calculations shall be in accordance with this Code or GS 1119

#### 29.8.4.4.1 Noncommunicating spaces.

Where the refrigerant-containing parts of a system are located in one or more spaces that do not communicate through permanent openings or HVAC ducts, the volume of the smallest, enclosed occupied space shall be used to determine the permissible quantity of refrigerant in the system.

#### 29.8.4.4.2 Communicating spaces.

Where an evaporator or condenser is located in an air duct system, the volume of the smallest, enclosed occupied space served by the duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

**Exception:** If airflow to any enclosed space cannot be reduced below one-quarter of its maximum, the entire space served by the air duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

#### 29.8.4.4.3 Plenums.

Where the space above a suspended ceiling is continuous and part of the supply or return air plenum system, this space shall be included in calculating the volume of the enclosed space.

### 29.8.5 MACHINERY ROOM, GENERAL REQUIREMENTS

#### 29.8.5.1 Design and construction.

Machinery rooms shall be designed and constructed in accordance with the Ghana Building Code and this clause.

#### 29.8.5.2 Openings.

Ducts and air handlers in the machinery room that operate at a lower pressure than the room shall be sealed to prevent any refrigerant leakage from entering the airstream.

#### 29.8.5.3 Refrigerant detector.

Refrigerant detectors in machinery rooms shall be provided as required by Clauses 605.8 and 605.17 of the Ghana Fire Code.

#### 29.8.5.4 Tests.

Periodic tests of the mechanical ventilating system shall be performed in accordance with manufacturer’s specifications and as required by the Code official.

#### 29.8.5.5 Fuel-burning appliances.

Fuel-burning appliances and equipment having open flames and that use combustion air from the machinery room shall not be installed in a machinery room.

**Exceptions:**

1. Where the refrigerant is carbon dioxide or water.
2. Fuel-burning appliances shall not be prohibited in the same machinery room with refrigerant-containing equipment or appliances where combustion air is ducted from outside the machinery room and sealed in such a manner as to prevent any refrigerant leakage from entering the combustion chamber, or where a refrigerant vapour detector is employed to automatically shut off the combustion process in the event of refrigerant leakage.

#### 29.8.5.6 Ventilation.

Machinery rooms shall be mechanically ventilated to the outdoors.
Exception: Where a refrigerating system is located outdoors more than 6096 mm (20 feet) from any building opening and is enclosed by a penthouse, lean-to or other open structure, natural or mechanical ventilation shall be provided. Location of the openings shall be based on the relative density of the refrigerant to air. The free-aperture cross-clause for the ventilation of the machinery room shall be not less than:

\[ F = \sqrt{G} \]  \hspace{1cm} \text{(Equation 29.8-1)}

For SI:

\[ F = 0.138 \sqrt{G} \]

where:

- \( F \) = The free opening area in square feet (m²).
- \( G \) = The mass of refrigerant in pounds (kg) in the largest system, any part of which is located in the machinery room.

29.8.5.6.1 Discharge location.
The discharge of the air shall be to the outdoors in accordance with Part 5. Exhaust from mechanical ventilation systems shall be discharged not less than 20 feet (6096 mm) from a property line or openings into buildings.

29.8.5.6.1.1 Indoor exhaust opening location.
Indoor mechanical exhaust intake openings shall be located where refrigerant leakage is likely to concentrate based on the refrigerant’s relative density to air, and the locations of the air current paths and refrigerating machinery.

29.8.5.6.2 Makeup air.
Provisions shall be made for makeup air to replace that being exhausted. Openings for makeup air shall be located to avoid intake of exhaust air. Supply and exhaust ducts to the machinery room shall not serve any other area, shall be constructed in accordance with Part 5 and shall be covered with corrosion-resistant screen of not less than 6.4 mm (\( \frac{1}{4} \) inch) mesh.

29.8.5.6.3 Ventilation rate.
For other than ammonia systems, the mechanical ventilation systems shall be capable of exhausting the minimum quantity of air both at normal operating and emergency conditions, as required by Clauses 29.8.5.6.3.1 and 29.8.5.6.3.2. The minimum required emergency ventilation rate for ammonia shall be 30 air changes per hour in accordance with IIAR2. Multiple fans or multispeed fans shall be allowed to produce the emergency ventilation rate and to obtain a reduced airflow for normal ventilation.

29.8.5.6.3.1 Quantity—normal ventilation.
During occupied conditions, the mechanical ventilation system shall exhaust the larger of the following:

1. Not less than 0.5 cfm per square foot (0.0025 m³/s • m²) of machinery room area or 20 cfm (0.009 m³/s) per person.

2. A volume required to limit the room temperature rise to 18°F (10°C) taking into account the ambient heating effect of all machinery in the room.

29.8.5.6.3.2 Quantity—emergency conditions.
Upon actuation of the refrigerant detector required in Clause 29.8.5.3, the mechanical ventilation system shall exhaust air from the machinery room in the following quantity:

\[ Q = 100 \times \sqrt{G} \]  \hspace{1cm} \text{(Equation 29.8-2)}

For SI:

\[ Q = 0.07 \times \sqrt{G} \]

where:

- \( Q \) = The airflow in cubic feet per minute (m³/s).
- \( G \) = The design mass of refrigerant in pounds (kg) in the largest system, any part of which is located in the machinery room.

29.8.5.7 Termination of relief devices.
Pressure relief devices, fusible plugs and purge systems located within the machinery room shall terminate outside of the structure at a location not less than 15 feet (4572 mm) above the adjoining grade level and not less
than 20 feet (6096 mm) from any window, ventilation opening or exit.

29.8.5.8 Ammonia discharge.
Pressure relief valves for ammonia systems shall discharge in accordance with this Code.

29.8.5.9 Emergency pressure control system.
Permanently installed refrigeration systems containing more than 6.6 pounds (3 kg) of flammable, toxic or highly toxic refrigerant or ammonia shall be provided with an emergency pressure control system in accordance with Code.

29.8.6 MACHINERY ROOM, SPECIAL REQUIREMENTS

29.8.6.1 General.
Where required by Clause 11.4.2, the machinery room shall meet the requirements of this clause in addition to the requirements of Clause 11.5.

1106.2 Elevated temperature.
There shall not be an open flame-producing device or continuously operating hot surface over 427°C (800°F) permanently installed in the room.

29.8.6.3 Ammonia room ventilation.
Ventilation systems in ammonia machinery rooms shall be operated continuously at the ventilation rate specified in Clause 11.5.6.3.

Exceptions:

1. Machinery rooms equipped with a vapour detector that will automatically start the ventilation system at the ventilation rate specified in this Code and that will actuate an alarm at a detection level not to exceed 1,000 ppm.

2. Machinery rooms conforming to the Class 1, Division 2, hazardous location classification requirements of Ghana Wiring Code.

29.8.6.4 Flammable refrigerants.
Where refrigerants of Groups A2, A3, B2 and B3 are used, the machinery room shall conform to the Class 1, Division 2, hazardous location classification requirements of NFPA 70 Ghana Wiring Code.

Exceptions:

1. Ammonia machinery rooms that are provided with ventilation in accordance with Clause 29.8.6.3.

2. Machinery rooms for systems containing Group A2L refrigerants that are in accordance with Clause 29.8.6.5.

29.8.6.5 Special requirements for Group A2L refrigerant machinery rooms.
Machinery rooms for systems containing Group A2L refrigerants shall comply with Clauses 29.8.6.5.1 through 29.8.6.5.3.

Exception: Machinery rooms conforming to the Class I, Division 2, hazardous location classification requirements of Ghana Wiring Code are not required to comply with Clauses 29.8.6.5.1 and 29.8.6.5.2.

29.8.6.5.1 Refrigerant detection system.
The machinery room shall be provided with a refrigerant detection system. The refrigerant detection system shall be in accordance with this Code and all of the following:

1. The detectors shall activate at or below a refrigerant concentration of 25% of the LFL.

2. Upon activation, the detection system shall activate the emergency ventilation system required by this Code.

3. The detection, signaling and control circuits shall be supervised.

29.8.6.5.2 Emergency ventilation system.
An emergency ventilation system shall be provided at the minimum exhaust rate specified in this Code or Table 29.8.6.5.2. Shutdown of the emergency ventilation system shall be by manual means.
### TABLE 29.8.6.5.2
**MINIMUM EXHAUST RATES**

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>Q(m/sec)</th>
<th>Q(cf m)</th>
</tr>
</thead>
<tbody>
<tr>
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### 29.8.6.5.3 Emergency ventilation system discharge.

The emergency ventilation system point of discharge to the atmosphere shall be located outside of the structure at not less than 4572 mm (15 feet) above the adjoining grade level and not less than 6096 mm (20 feet) from any window, ventilation opening or exit.

### 29.8.6.6 Remote controls.

Remote control of the mechanical equipment and appliances located in the machinery room shall comply with Clauses 11.6.6.1 and 11.6.6.2.

#### 29.8.6.6.1 Refrigeration system emergency shutoff.

A clearly identified switch of the break-glass type or with an approved tamper-resistant cover shall provide off-only control of refrigerant compressors, refrigerant pumps, and normally closed, automatic refrigerant valves located in the machinery room. Additionally, this equipment shall be automatically shut off whenever the refrigerant vapour concentration in the machinery room exceeds the vapour detector’s upper detection limit or 25 percent of the LEL, whichever is lower.

#### 29.8.6.6.2 Ventilation system.

A clearly identified switch of the break-glass type or with an approved tamper-resistant cover shall provide on-only control of the machinery room ventilation fans.

### 29.8.6.7 Emergency signs and labels.

Refrigeration units and systems shall be provided with approved emergency signs, charts, and labels in accordance with the Ghana Fire Code.

### 29.8.7 REFRIGERANT PIPING

#### 29.8.7.1 General.

The design of refrigerant piping shall be in accordance with this Code. Refrigerant piping shall be installed, tested and placed in operation in accordance with this part.

#### 29.8.7.2 Piping location.

Refrigerant piping that crosses an open space that affords passageway in any building shall be not less than 2210 mm (7 feet 3 inches) above the floor unless the piping is located against the ceiling of such space. Refrigerant piping shall not be placed in any of the following:

1. A fire-resistance-rated exit access corridor.
2. An interior exit stairway.
3. An interior exit ramp.
4. An exit passageway.
5. An elevator, dumbwaiter or other shaft containing a moving object.
6. A shaft that has one or more openings into a fire-resistance-rated exit access corridor, interior exit stairway or ramp or exit passageway.

#### 29.8.7.2.1 Piping in concrete floors.

Refrigerant piping installed in concrete floors shall be encased in pipe ducts. The piping shall be isolated and supported to prevent damaging vibration, stress and corrosion.

#### 29.8.7.2.2 Refrigerant penetrations.

Refrigerant piping shall not penetrate floors, ceilings or roofs.

**Exceptions:**

1. Penetrations connecting the basement and the first floor.
2. Penetrations connecting the top floor and a machinery penthouse or roof installation.

3. Penetrations connecting adjacent floors served by the refrigeration system.

4. Penetrations by piping in a direct system where the refrigerant quantity does not exceed Table 11.3.1 for the smallest occupied space through which the piping passes.

5. In other than industrial occupancies and where the refrigerant quantity exceeds this code for the smallest space, penetrations for piping that connects separate pieces of equipment that are either:

   5.1. Enclosed by an approved gas-tight, fire-resistive duct or shaft with openings to those floors served by the refrigeration system.

   5.2. Located on the exterior of the building where vented to the outdoors or to the space served by the system and not used as an air shaft, closed court or similar space.

29.8.7.3 Pipe enclosures.

Rigid or flexible metal enclosures or pipe ducts shall be provided for soft, annealed copper tubing and used for refrigerant piping erected on the premises and containing other than Group A1 or B1 refrigerants. Enclosures shall not be required for connections between condensing units and the nearest riser box(es), provided such connections do not exceed 1829 mm (6 feet) in length.

29.8.7.4 Condensation.

Refrigerating piping and fittings, brine piping and fittings that, during normal operation, will reach a surface temperature below the dew point of the surrounding air, and are located in spaces or areas where condensation will cause a safety hazard to the building occupants, structure, electrical equipment or any other equipment or appliances, shall be protected in an approved manner to prevent such damage.

29.8.7.5 Materials for refrigerant pipe and tubing.

Piping materials shall be as set forth in Clauses 29.8.7.5.1 through 29.8.7.5.5.

29.8.7.5.1 Steel pipe.

Carbon steel pipe with a wall thickness not less than Schedule 80 shall be used for Group A2, A3, B2 or B3 refrigerant liquid lines for sizes 38 mm (1.5 inches) and smaller. Carbon steel pipe with a wall thickness not less than Schedule 40 shall be used for Group A1 or B1 refrigerant liquid lines 152 mm (6 inches) and smaller, Group A2, A3, B2 or B3 refrigerant liquid lines sizes 51 mm (2 inches) through 152 mm (6 inches) and all refrigerant suction and discharge lines 152 mm (6 inches) and smaller. Type F steel pipe shall not be used for refrigerant lines having an operating temperature less than -29°C (-20°F).

29.8.7.5.2 Copper and copper-alloy pipe.

Standard iron-pipe size, copper and copper-alloy (not less than 80-percent copper) pipe shall conform to ASTM B42 and ASTM B43.

29.8.7.5.3 Copper tube.

Copper tube used for refrigerant piping erected on the premises shall be seamless copper tube of Type ACR (hard or annealed) complying with ASTM B280 or ASTM B819. Annealed temper copper tube shall not be used in sizes larger than a 51 mm (2-inch) nominal size. Mechanical joints other than press-connect joints listed for refrigerant piping shall not be used on annealed temper copper tube in sizes larger than 22.2 mm (7/8-inch) OD size.

29.8.7.5.4 Copper tubing joints.

Copper tubing joints used in refrigerating systems containing Group A2, A3, B2 or B3 refrigerants shall be brazed. Soldered joints shall not be used in such refrigerating systems.
29.8.7.5.5 Aluminum tube.
Type 3003-0 aluminum tubing with high-pressure fittings shall not be used with methyl chloride and other refrigerants known to attack aluminum.

29.8.7.6 Joints and refrigerant-containing parts in air ducts.
Joints and all refrigerant-containing parts of a refrigerating system located in an air duct of an air-conditioning system carrying conditioned air to and from human-occupied space shall be constructed to withstand, without leakage, a pressure of 150 percent of the higher of the design pressure or pressure relief device setting.

29.8.7.7 Exposure of refrigerant pipe joints.
Refrigerant pipe joints erected on the premises shall be exposed for visual inspection prior to being covered or enclosed.

29.8.7.8 Stop valves.
Systems containing more than 3 kg (6.6 pounds) of a refrigerant in systems using positive-displacement compressors shall have stop valves installed as follows:

1. At the inlet of each compressor, compressor unit or condensing unit.
2. At the discharge outlet of each compressor, compressor unit or condensing unit and of each liquid receiver.

Exceptions:
1. Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge in a receiver or heat exchanger.
2. Systems that are equipped with provisions for pumpout of the refrigerant using either portable or permanently installed recovery equipment.
3. Self-contained systems.

29.8.7.8.1 Liquid receivers.
Systems containing 100 pounds (45 kg) or more of a refrigerant, other than systems utilizing nonpositive displacement compressors, shall have stop valves, in addition to those required by Clause 29.8.7.8, on each inlet of each liquid receiver. Stop valves shall not be required on the inlet of a receiver in a condensing unit, nor on the inlet of a receiver that is an integral part of the condenser.

29.8.7.8.2 Copper tubing.
Stop valves used with soft annealed copper tubing or hard-drawn copper tubing 22.2 mm (7/8-inch) OD standard size or smaller shall be securely mounted, independent of tubing fastenings or supports.

29.8.7.8.3 Identification.
Stop valves shall be identified where their intended purpose is not obvious. Numbers shall not be used to label the valves, unless a key to the numbers is located near the valves.

29.8.8 FIELD TEST

29.8.8.1 General.
Every refrigerant-containing part of every system that is erected on the premises, except compressors, condensers, vessels, evaporators, safety devices, pressure gauges and control mechanisms that are listed and factory tested, shall be tested and proved tight after complete installation, and before operation. Tests shall include both the high and low-pressure sides of each system at not less than the lower of the design pressures or the setting of the pressure relief device(s). The design pressures for testing shall be those listed on the condensing unit, compressor or compressor unit nameplate, as required by this Code.

Exceptions:
1. Gas bulk storage tanks that are not permanently connected to a refrigeration system.
2. Systems erected on the premises with copper tubing not exceeding 15.8 mm (5/8-inch) OD, with wall thickness as required by this Code shall be tested in accordance with Clause 29.8.8.1, or by means of refrigerant charged into the system at the saturated vapour pressure of the refrigerant at 70°F (21°C) or higher.

1152
3. Limited-charge systems equipped with a pressure relief device, erected on the premises, shall be tested at a pressure not less than one and one-half times the pressure setting of the relief device. If the equipment or appliance has been tested by the manufacturer at one and one-half times the design pressure, the test after erection on the premises shall be conducted at the design pressure.

29.8.8.1 Booster compressor.
Where a compressor is used as a booster to obtain an intermediate pressure and discharges into the suction side of another compressor, the booster compressor shall be considered to be a part of the low side, provided that it is protected by a pressure relief device.

29.8.8.2 Test gases.
Tests shall be performed with an inert dried gas including, but not limited to, nitrogen and carbon dioxide. Oxygen, air, combustible gases and mixtures containing such gases shall not be used.

Exception: The use of air is allowed to test R-717, ammonia, systems provided that they are subsequently evacuated before charging with refrigerant.

29.8.8.3 Test apparatus.
The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gauge on the outlet side.

29.8.8.4 Declaration.
A certificate of test shall be provided for all systems containing 25 kg (55 pounds) or more of refrigerant. The certificate shall give the name of the refrigerant and the field test pressure applied to the high side and the low side of the system. The certification of test shall be signed by the installer and shall be made part of the public record.

29.8.9 PERIODIC TESTING

29.8.9.1 Testing required.
The following emergency devices and systems shall be periodically tested in accordance with the manufacturer's instructions and as required by the Code official:

1. Treatment and flaring systems.
2. Valves and appurtenances necessary to the operation of emergency refrigeration control boxes.
3. Fans and associated equipment intended to operate emergency ventilation systems.
4. Detection and alarm systems.

29.9 SOLAR THERMAL SYSTEMS

User note:
This clause addresses solar thermal systems, not photovoltaic systems. The provisions are intended to protect property and life from the hazards associated with high-temperature liquids, pressurized systems and toxic fluids. There are also provisions to protect the building structure and the solar thermal system components from damage.

29.9.1 GENERAL

29.9.1.1 Scope.
This part shall govern the design, construction, installation, alteration and repair of solar thermal systems, equipment and appliances intended to utilize solar energy for space heating or cooling, domestic hot water heating, swimming pool heating or process heating.

29.9.1.2 Potable water supply.
Potable water supplies to solar systems shall be protected against contamination in accordance with the GWSC RULES.

29.9.1.3 Heat exchangers.
Heat exchangers used in domestic water-heating systems shall be approved for the intended use. The system shall have adequate protection to ensure that the potability of the water supply and distribution system is properly safeguarded.

29.9.1.4 Solar thermal equipment and appliances.
Solar thermal equipment and appliances shall conform to the requirements of this part. Solar thermal systems shall be listed and labeled in
accordance with this Code and shall be installed in accordance with the manufacturer’s instructions.

29.9.1.4.1 Collectors and panels.
Solar thermal collectors and panels shall be listed and labeled in accordance with Ghana Labeling Rules.

29.9.2 DESIGN AND INSTALLATION

29.9.2.1 General.
The design and installation of solar thermal systems shall comply with Clauses 29.9.2.1 through 29.9.2.8. Solar thermal systems shall be listed and labeled in accordance with Ghana Labeling Rules and shall be installed in accordance with the manufacturer’s instructions.

29.9.2.2 Access.
Access shall be provided to solar thermal equipment for maintenance. Solar thermal systems and appurtenances shall not obstruct or interfere with the operation of any doors, windows or other building components requiring operation or access. Roof-mounted solar thermal equipment shall not obstruct or interfere with the operation of roof-mounted equipment, appliances, chimneys, roof hatches, smoke vents, skylights and other roof penetrations and openings.

29.9.2.3 Pressure and temperature.
Solar thermal system components containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with pressure and temperature relief valves or pressure relief valves. System components shall have a working pressure rating of not less than the setting of the pressure relief device.

29.9.2.3.1 Relief device.
Each clause of the system in which excessive pressures are capable of developing shall have a relief device located so that a clause cannot be valved off or otherwise isolated from a relief device. For indirect solar systems, pressure relief valves in solar loops shall also comply with this Code.

29.9.2.3.2 Vacuum.
System components that might be subjected to a vacuum while in operation or during shutdown shall be designed to withstand such vacuum or shall be protected with vacuum relief valves.

29.9.2.4.1 Drain-back systems.
Drain-back systems shall be designed and installed to allow for manual gravity draining of fluids from areas subject to freezing to locations not subject to freezing, and air filling of the components and piping. Such piping and components shall maintain a horizontal slope in the direction of flow of not less than one-fourth unit vertical in 12 units horizontal (2-percent slope). Piping and components subject to manual gravity draining shall permit subsequent air filling upon drainage and air storage or venting upon refilling.

29.9.2.5 Protection of potable water.
Where a solar thermal system heats potable water to supply a potable hot water distribution or any other type of heating system, the solar thermal system shall be in accordance with Clauses 29.9.2.5.1 through 29.9.2.5.3 as applicable.

29.9.2.5.1 Indirect systems.
Water supplies of any type shall not be connected to the solar heating loop of an indirect solar thermal hot water heating system. This requirement shall not prohibit the presence of inlets or outlets on the solar heating loop for the purposes of servicing the fluid in the solar heating loop.

29.9.2.5.2 Direct systems for potable water distribution systems.
Where a solar thermal system directly heats potable water for a potable water distribution system, the pipe, fittings, valves and other components that are in contact with the potable water in the system shall comply with the requirements of this Code.

29.9.2.5.3 Direct systems for other than potable water distribution systems.
Where a solar thermal system directly heats water for a system other than a potable water distribution system, a potable water supply connected to such system shall be protected against backflow in accordance with best practise.

29.9.2.6 Protection of equipment.
Solar thermal equipment exposed to vehicular traffic shall be installed not less than 1829 mm (6 feet) above the finished floor.
Exception: This clause shall not apply where the equipment is protected from motor vehicle impact.

29.9.2.7 Protection of structure.
In the process of installing or repairing any part of a solar thermal system, the building or structure shall be left in a safe structural condition in accordance with Clause 29.9.2.7.1 and 29.9.2.7.2.

29.9.2.7.2 Penetrations.
Roof and wall penetrations shall be flashed and sealed to prevent entry of water, rodents and insects.

29.9.2.8 Equipment.
The solar thermal system shall be equipped in accordance with the requirements of Clauses 29.9.2.8.1 through 29.9.2.8.5.3.

29.9.2.8.1 Collectors and panels.
Solar collectors and panels shall comply with Clauses 29.9.2.8.1.1 through 29.9.2.8.1.4.

29.9.2.8.1.1 Design.
Solar thermal collectors and panels shall be listed and labeled in accordance with ICC 901/SRCC 100.

29.9.2.8.1.2 Rooftop-mounted solar thermal collectors and systems.
The roof shall be constructed to support the loads imposed by roof-mounted solar collectors. Where mounted on or above the roof covering, the collector array and supporting construction shall be constructed of noncombustible materials or fire-retardant-treated wood to the extent required for the type of roof construction of the building to which the collectors are accessory.

29.9.2.8.1.3 Collectors as roof covering.
Roof-mounted solar collectors that also serve as a roof covering shall conform to the requirements for roof coverings in accordance with the Ghana Building Code

Exception: The use of plastic solar collector covers shall be limited to those approved light-transmitting plastics meeting the requirements for plastic roof panels in accordance with the Ghana Building Code.

29.9.2.8.1.4 Collector sensors.
Collector sensor installation, sensor location and the protection of exposed sensor wires from degradation shall be in accordance with ICC 900/SRCC 300, NFPA 70 (Ghana Wiring Code) and the collector manufacturer’s instructions.

29.9.2.8.2 Ducts.
Ducts utilized in solar heating and cooling systems shall be constructed and installed in accordance with manufacturer’s specification.

29.9.2.8.2.1 Filtering.
Air transported to occupied spaces through dust-producing materials by means other than natural convection shall be filtered before entering the occupied space.

29.9.2.8.3 Piping.
Potable piping shall be installed in accordance with this Code. Hydronic piping shall be installed in accordance with Part 7 of this Code.

29.9.2.8.3.1 Piping insulation.
Piping shall be insulated in accordance with the requirements of this Code. Exterior insulation shall be protected from degradation. The entire solar loop shall be insulated. Where split-style insulation is used, the seam shall be sealed. Fittings shall be fully insulated.

Exceptions:

1. Those portions of the piping that are used to help prevent the system from overheating shall not be required to be insulated.

2. Those portions of piping that are exposed to solar radiation, made of the same material as the solar collector absorber plate and covered in the same manner as the solar collector absorber, or that are used to collect additional solar energy, shall not be required to be insulated.

3. Piping in solar thermal systems using unglazed solar collectors to heat a swimming pool shall not be required to be insulated.
29.9.2.8.4 Heat exchangers.
Heat exchangers used in domestic water-heating systems shall be approved for the intended use. The system shall have adequate protection to ensure that the potability of the water supply and distribution system is properly safeguarded.

29.9.2.8.4.1 Double-wall heat exchangers.
Heat exchangers utilizing a non-food-grade fluid shall be separated from the potable water by double-wall construction. An air gap open to the atmosphere shall be provided between the two walls. The discharge location from the double-wall heat exchanger shall be visible.

29.9.2.8.4.2 Single-wall heat exchangers.
Food-grade fluids shall be used as the heat transfer fluid in single-wall heat exchangers.

29.9.2.8.5 Water heaters and hot water storage tanks.
Auxiliary water heaters, boilers and water storage tanks associated with solar thermal systems shall comply with Part 7.

29.9.2.8.5.1 Hot water storage tank insulation.
Hot water storage tanks shall be insulated and such insulation shall have an R-value of not less than R-12.5.

29.9.2.8.5.2 Outdoor locations.
Storage tanks and heating equipment installed in outdoor locations shall be designed for outdoor installation.

29.9.2.8.5.3 Storage tank sensors.
Storage tank sensors shall comply with this Code.

29.9.2.8.6 Solar loop.
Solar loops shall be in accordance with Clauses 29.9.2.8.6.1 and 29.9.2.8.6.2.

29.9.2.8.6.1 Solar loop isolation.
Valves shall be installed to allow the solar loop to be isolated from the remainder of the system.

29.9.2.8.6.2 Drain and fill valve caps.
Drain caps shall be installed on drain and fill valves.

29.9.2.8.7 Expansion tanks.
Liquid single-phase solar energy systems shall be equipped with expansion tanks sized in accordance with this Code, except that additional expansion tank acceptance volume equal to the total volume of liquid contained in the installed solar collectors and piping above the collectors shall be included.

29.9.3 HEAT TRANSFER FLUIDS

29.9.3.1 Flash point.
The flash point of the heat transfer fluid utilized in a solar system shall be not less than 28°C (50°F) above the design maximum nonoperating (no-flow) temperature of the fluid attained in the collector.

29.9.3.2 Heat transfer fluids.
Heat transfer gases and liquids shall be rated to withstand the system’s maximum design temperature under operating conditions without degradation. Heat transfer fluids shall be in accordance with this Code.

29.9.3.3 Food-grade additives.
Any food-grade fluid used as a heat transfer fluid containing additives shall be third-party listed by an approved agency.

29.9.3.4 Toxicity.
The use of toxic fluids shall comply with the Ghana Fire Code.

29.9.3.5 Flammable gases and liquids.
A flammable liquid or gas shall not be utilized as a heat transfer fluid. The flash point of liquids used in occupancies classified in Group H or F shall not be lower unless approved.

29.9.4 LABELING

29.9.4.1 Collectors.
Factory-built collectors shall bear a label showing the manufacturer’s name and address, model number and serial number.

29.9.4.2 Water storage tanks.
Pressurized water storage tanks shall bear a label showing the manufacturer’s name and address, model number, serial number, storage unit maximum and minimum allowable operating temperatures, and storage unit maximum and minimum allowable operating pressures. The label shall clarify that these specifications apply only to the water storage tanks.

29.9.4.3 Fluid safety labeling.
Drain and fill valves shall be labeled with a description and warning that identifies the fluid in that loop as “Potable Water,” “Food-Grade Fluid,” “Non-Food-Grade Fluid” or “Toxic.”
Labeling shall also be provided that reads as follows: “Fluid could be discharged at high temperature or pressure or both. Unauthorized alterations to this system could result in a health hazard or a hazardous condition.”

29.9.4.4 Heat exchangers.
Heat exchangers shall be labeled to indicate the heat exchanger type with one of the following:
1. “Single-wall without leak protection.”
2. “Double-wall without leak protection.”
3. “Double-wall with leak protection.”

PART 30: PLUMBING SYSTEMS

User note:
About this part: Plumbing systems are another key element of any building. Part 30 provides the necessary number of plumbing fixtures, including water closets, lavatories, bathtubs and showers. The quality and design of each fixture must be in accordance with this Code.

30.1 GENERAL
30.1.1 Scope.
The provisions of this Part shall govern the design, construction, erection and installation of plumbing components, appliances, equipment and systems used in buildings and structures covered by this Code. Toilet and bathing rooms shall be constructed in accordance with this Code. Private sewage disposal systems shall conform to this Code.

The code shall govern the use and maintenance of plumbing components, appliances, equipment and systems. This part shall govern the alteration, repair, relocation, replacement and addition of plumbing components, appliances, equipment and systems.

30.2 MINIMUM PLUMBING FACILITIES

Plumbing fixtures shall be provided in the minimum number as shown in Table 30.2.1 based on the actual use of the building or space. Uses not shown in Table 30.2.1 shall be considered individually by the Code official. The number of occupants shall be determined by this Code.

30.2.1 Fixture calculations.
To determine the occupant load of each sex, the total occupant load shall be divided in half. To determine the required number of fixtures, the fixture ratio or ratios for each fixture type shall be applied to the occupant load of each sex in accordance with Table 30.2.1. Fractional numbers resulting from applying the fixture ratios of Table 30.2.1 shall be rounded up to the next whole number. For calculations involving multiple occupancies, such fractional numbers for each occupancy shall first be summed and then rounded up to the next whole number.

Exception: The total occupant load shall not be required to be divided in half where approved statistical data indicate a distribution of the sexes of other than 50 percent of each sex.

30.2.1.2 Single-user toilet facility and bathing room fixtures.
The plumbing fixtures located in single-user toilet facilities and bathing rooms, including family or assisted-use toilet and bathing rooms that are required by Table 30.2.1 shall contribute toward the total number of required plumbing fixtures for a building or tenant space. Single-user toilet facilities and bathing rooms, and family or assisted-use toilet rooms
and bathing rooms shall be identified for use by either sex.

30.2.1.3 Lavatory distribution.
Where two or more toilet rooms are provided for each sex, the required number of lavatories shall be distributed proportionately to the required number of water closets.

30.2.2 Separate facilities.
Where plumbing fixtures are required, separate facilities shall be provided for each sex.

Exceptions:

1. Separate facilities shall not be required for dwelling units and sleeping units.

2. Separate facilities shall not be required in structures or tenant spaces with a total occupant load, including both employees and customers, of 15 or fewer.

3. Separate facilities shall not be required in mercantile occupancies in which the maximum occupant load is 100 or fewer.

4. Separate facilities shall not be required in business occupancies in which the maximum occupant load is 25 or fewer.

30.2.2.1 Family or assisted-use toilet facilities serving as separate facilities.
Where a building or tenant space requires a separate toilet facility for each sex and each toilet facility is required to have only one water closet, two family or assisted-use toilet facilities shall be permitted to serve as the required separate facilities. Family or assisted-use toilet facilities shall not be required to be identified for exclusive use by either sex as required by Clause 30.2.4.

30.2.3 Employee and public toilet facilities.
For structures and tenant spaces intended for public utilization, customers, patrons and visitors shall be provided with public toilet facilities. Employees associated with structures and tenant spaces shall be provided with toilet facilities. The number of plumbing fixtures located within the required toilet facilities shall be provided in accordance with Clause 30.2 for all users. Employee toilet facilities shall be either separate or combined employee and public toilet facilities.

Exception: Public toilet facilities shall not be required for:

1. Parking garages where operated without parking attendants.

2. Structures and tenant spaces intended for quick transactions, including takeout, pickup and drop-off, having a public access area less than or equal to 28 m² (300 square feet).

30.2.3.1 Access.
The route to the public toilet facilities required by Clause 30.2.3 shall not pass through kitchens, storage rooms or closets. Access to the required facilities shall be from within the building or from the exterior of the building. Routes shall comply with the accessibility requirements of this Code. The public shall have access to the required toilet facilities at all times that the building is occupied.

30.2.3.2 Prohibited toilet room location.
Toilet rooms shall not open directly into a room used for the preparation of food for service to the public.

30.2.3.3 Location of toilet facilities in occupancies other than malls.
In occupancies other than covered and open mall buildings, the required public and employee toilet facilities shall be located not more than one storey above or below the space required to be provided with toilet facilities, and the path of travel to such facilities shall not exceed a distance of 152 m (500 feet).

Exception: The location and maximum distances of travel to required employee facilities in factory and industrial occupancies are permitted to exceed that required by this clause, provided that the location and maximum distance of travel are approved.
30.2.3.4 Location of toilet facilities in malls.

In covered and open mall buildings, the required public and employee toilet facilities shall be located not more than one storey above or below the space required to be provided with toilet facilities, and the path of travel to such facilities shall not exceed a distance of 91 mm (300 feet). In mall buildings, the required facilities shall be based on total square footage (m²) within a covered mall building or within the perimeter line of an open mall building, and facilities shall be installed in each individual store or in a central toilet area located in accordance with this clause. The maximum distance of travel to central toilet facilities in mall buildings shall be measured from the main entrance of any store or tenant space. In mall buildings, where employees’ toilet facilities are not provided in the individual store, the maximum distance of travel shall be measured from the employees’ work area of the store or tenant space.

30.2.3.5 Door locking.

Where a toilet room is provided for the use of multiple occupants, the escape door for the room shall not be lockable from the inside of the room. This clause does not apply to family or assisted-use toilet rooms.

30.2.4 Signage.

Required public facilities shall be provided with signs that designate the sex as required by Clause 30.2.2. Signs shall be readily visible and located on the entrance door or wall to each toilet facility. Signs for accessible toilet facilities shall comply with GS 1119.

30.2.4.1 Directional signage.

Directional signage indicating the route to the required public toilet facilities shall be posted in a lobby, corridor, aisle or similar space, such that the sign can be readily seen from the main entrance to the building or tenant space.

30.2.5 Drinking fountain location.

Drinking fountains shall not be required to be located in individual tenant spaces provided that public drinking fountains are located within a distance of travel of 152 m (500 feet) of the most remote location in the tenant space and not more than one storey above or below the tenant space. Where the tenant space is in a covered or open mall, such distance shall not exceed 91 440 mm (300 feet). Drinking fountains shall be located on an accessible route.

30.2.6 Small occupancies.

Drinking fountains shall not be required for an occupant load of 15 or fewer.

[P] TABLE 30.2.1

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<tr>
<th>MINIMUM NUMBER OF REQUIRED PLUMBING FIXTURES&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(See Clauses 30.2.1.1 and 30.2.2)</td>
</tr>
</tbody>
</table>

1159
<table>
<thead>
<tr>
<th>No.</th>
<th>CLASSIFICATION</th>
<th>DESCRIPTION</th>
<th>WATER CLOSETS (URINALS SEE SECTION 424.2 OF THE INTERNATIONAL PLUMBING CODE)</th>
<th>LAVATORIES</th>
<th>BATHTUBS/SHOWERS</th>
<th>DRINKING FOUNTAINS (SEE SECTION 419 OF THE INTERNATIONAL PLUMBING CODE)</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>1 per 200</td>
</tr>
<tr>
<td>1</td>
<td>Assembly</td>
<td>Theaters and other buildings for the performing arts and motion picturesa</td>
<td>1 per 125</td>
<td>1 per 65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nightclubs, bars, taverns, dance halls and buildings for similar purposesa</td>
<td>1 per 40</td>
<td>1 per 40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Restaurants, banquet halls and food courtsa</td>
<td>1 per 75</td>
<td>1 per 75</td>
<td>1 per 200</td>
<td>—</td>
<td>1 per 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casino gaming areas</td>
<td>1 per 100 for the first 400 and 1 per 250 for the remainder exceeding 400</td>
<td>1 per 50 for the first 400 and 1 per 150 for the remainder exceeding 400</td>
<td>1 per 250 for the first 750 and 1 per 500 for the remainder exceeding 750</td>
<td>—</td>
<td>1 per 1,000</td>
</tr>
</tbody>
</table>

(P) TABLE 30.2.1—(continued)

MINIMUM NUMBER OF REQUIRED PLUMBING FIXTURES a

(See Clauses 30.2.1.1 and 30.2.2)
<table>
<thead>
<tr>
<th>No.</th>
<th>Classification</th>
<th>Description</th>
<th>Water Closets (Urinals see Section 424.2 of the International Plumbing Code)</th>
<th>Lavadories</th>
<th>Bathtubs/Shower (see Section 418 of the International Plumbing Code)</th>
<th>Drinking Fountains (see Section 410 of the International Plumbing Code)</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male per 125</td>
<td>Female</td>
<td>1 per 200</td>
<td>1 per 500</td>
<td>1 service sink</td>
</tr>
<tr>
<td>1</td>
<td>Assembly</td>
<td>Auditoriums without permanent seating, art galleries, exhibition halls, museums, lecture halls, libraries, arcades and gymnasiastra</td>
<td>1 per 65</td>
<td>1 per 200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Passenger terminals and transportation facilitiesb</td>
<td>1 per 500</td>
<td>1 per 750</td>
<td></td>
<td>1 per 1,000</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Places of worship and other religious servicesc</td>
<td>1 per 150</td>
<td>1 per 200</td>
<td></td>
<td>1 per 1,000</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coliseums, arenas, skating rinks, pools and tennis courts for indoor sporting events and activitiesd</td>
<td>1 per 75 for the first 1,500</td>
<td>1 per 40 for the first 1,520 and 1 per 60 for the remainder exceeding 1,520</td>
<td>1 per 150</td>
<td></td>
<td>1 per 1,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stadiums, amusement parks, bleachers and grandstands for outdoor sporting events and activitiesf</td>
<td>1 per 75 for the first 1,500</td>
<td>1 per 40 for the first 1,520 and 1 per 60 for the remainder exceeding 1,520</td>
<td>1 per 200</td>
<td></td>
<td>1 per 1,000</td>
</tr>
<tr>
<td>2</td>
<td>Business</td>
<td>Buildings for the transaction of business, professional services, other services involving merchandise, office buildings, banks, light industrial, ambulatory care and similar uses</td>
<td>1 per 25 for the first 50 and 1 per 50 for the remainder exceeding 50</td>
<td>1 per 40 for the first 80 and 1 per 80 for the remainder exceeding 80</td>
<td>1 per 100</td>
<td></td>
<td>1 service sink</td>
</tr>
<tr>
<td>3</td>
<td>Educational</td>
<td>Educational facilities</td>
<td>1 per 50</td>
<td>1 per 50</td>
<td></td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td>4</td>
<td>Factory and industrial</td>
<td>Structures in which occupants are engaged in work fabricating, assembly or processing of products or materials</td>
<td>1 per 100</td>
<td>1 per 100</td>
<td></td>
<td>1 per 400</td>
<td>1 service sink</td>
</tr>
<tr>
<td>5</td>
<td>Institutional</td>
<td>Custodial care facilities</td>
<td>1 per 10</td>
<td>1 per 10</td>
<td>1 per 8</td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medical care recipients in hospitals and nursing homesa</td>
<td>1 per room²</td>
<td>1 per room²</td>
<td>1 per 15</td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employees in hospitals and nursing homesa</td>
<td>1 per 25</td>
<td>1 per 35</td>
<td></td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visitors in hospitals and nursing homesa</td>
<td>1 per 75</td>
<td>1 per 100</td>
<td></td>
<td>1 per 500</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prisonsa</td>
<td>1 per cell</td>
<td>1 per 15</td>
<td>1 per 100</td>
<td></td>
<td>1 service sink</td>
</tr>
</tbody>
</table>

(continued)
### TABLE 30.2.1—continued

**MINIMUM NUMBER OF REQUIRED PLUMBING FIXTURES**

*(See Clauses 30.2.1.1 and 30.2.2)*

<table>
<thead>
<tr>
<th>No.</th>
<th>CLASSIFICATION</th>
<th>DESCRIPTION</th>
<th>WATER CLOSETS (URINALS SEE SECTION 404.2 OF THE INTERNATIONAL PLUMBING CODE)</th>
<th>LAVATORIES</th>
<th>BATHTUBS OR SHOWERS</th>
<th>DRINKING FOUNTAINS (SEE SECTION 410 OF THE INTERNATIONAL PLUMBING CODE)</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Institutional</td>
<td>Reformatories, detention centers and correctional centers&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 per 15</td>
<td>1 per 15</td>
<td>1 per 15</td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employees in reformatories, detention centers and correctional centers&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 per 25</td>
<td>1 per 35</td>
<td>—</td>
<td>1 per 100</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adult day care and child day care</td>
<td>1 per 15</td>
<td>1 per 15</td>
<td>1</td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td>6</td>
<td>Mercantile</td>
<td>Retail stores, service stations, shops, salesrooms, markets and shopping centers</td>
<td>1 per 500</td>
<td>1 per 750</td>
<td>—</td>
<td>1 per 1,000</td>
<td>1 service sink&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hotels, motels, boarding houses (transient)</td>
<td>1 per sleeping unit</td>
<td>1 per sleeping unit</td>
<td>1 per sleeping unit</td>
<td>—</td>
<td>1 service sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dormitories, fraternities, sororities and boarding houses (not transient)</td>
<td>1 per 10</td>
<td>1 per 10</td>
<td>1 per 8</td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td>7</td>
<td>Residential</td>
<td>Apartment house</td>
<td>1 per dwelling unit</td>
<td>1 per dwelling unit</td>
<td>1 per dwelling unit</td>
<td>—</td>
<td>1 kitchen sink per dwelling unit; 1 automatic clothes washer connection per 20 dwelling units</td>
</tr>
<tr>
<td></td>
<td></td>
<td>One- and two-family dwellings and lodging houses with five or fewer guestrooms</td>
<td>1 per dwelling unit</td>
<td>1 per 10</td>
<td>1 per dwelling unit</td>
<td>—</td>
<td>1 kitchen sink per dwelling unit; 1 automatic clothes washer connection per dwelling unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Congregate living facilities with 16 or fewer persons</td>
<td>1 per 10</td>
<td>1 per 10</td>
<td>1 per 8</td>
<td>1 per 100</td>
<td>1 service sink</td>
</tr>
<tr>
<td>8</td>
<td>Storage</td>
<td>Structures for the storage of goods, warehouses, storehouses and freight depots, low and moderate hazard</td>
<td>1 per 100</td>
<td>1 per 100</td>
<td>—</td>
<td>1 per 1,000</td>
<td>1 service sink</td>
</tr>
</tbody>
</table>

**Note:**

a. The fixtures shown are based on one fixture being the minimum required for the number of persons indicated or any fraction of the number of persons indicated. The number of occupants shall be determined by this Code.

b. Toilet facilities for employees shall be separate from facilities for inmates or care recipients.

c. A single-occupant toilet room with one water closet and one lavatory serving not more than two adjacent patient sleeping units shall be permitted, provided that each patient sleeping unit has direct access to the toilet room and provisions for privacy for the toilet room user are provided.

d. The occupant load for seasonal outdoor seating and entertainment areas shall be included when determining the minimum number of facilities required.

e. For business and mercantile classifications with an occupant load of 15 or fewer, a service sink shall not be required.

f. The required number and type of plumbing fixtures for outdoor swimming pools shall be in accordance with Clause 609 of the International Swimming Pool and Spa Code.
30.3 BASIC PRINCIPLES

30.3.1 Potable water
All premises intended for human habitation, occupancy, or use shall be provided with a supply of potable water. This water supply shall not be connected with unsafe water resources, nor shall it be subject to the hazards of backflow.

30.3.1.2 Water provision
Plumbing fixtures, devices and appurtenances shall be provided with water in sufficient volume and at pressures adequate to enable them to function properly and without undue noise under normal conditions of use. There should be at least a residual head of 0.018 N/mm$^2$ at the consumer’s tap.

Note: The residual head shall be taken at the highest/farthest outlets in the building.

30.3.1.3 Water conservation
Plumbing system shall be designed, installed and adjusted to use the optimum quantity of water consistent with proper performance and cleaning.

30.3.1.4 Safety devices
Plumbing system shall be designed and installed with safety devices to safeguard against dangers from contamination, explosion, overheating, etc.

30.3.1.5 Plumbing fixtures
It is recommended that each family dwelling unit should have at least one water closet, one lavatory, one kitchen wash place or a sink, and one bathing wash place or shower to meet the basic requirements of sanitation and personal hygiene.

30.3.1.6 Drainage system
The drainage system shall be designed, installed and maintained to guard against fouling, deposit of solids and clogging and with adequate cleanouts so arranged that the pipes may be readily cleaned.

30.3.1.7 Materials and workmanship
The plumbing system shall have durable material, free from defective workmanship and so designed and installed as to give satisfactory service for its reasonable expected life.

30.3.1.8 Fixture traps and vent pipes
Each fixture directly connected to the drainage system shall be equipped with a liquid seal trap. Trap seals shall be maintained to prevent sewer gas, other potentially dangerous or noxious fumes, or vermin from entering the building. Further, the drainage system shall be designed to provide an adequate circulation of air in all pipes with no danger of siphonage, aspiration, or forcing of trap seals under conditions of ordinary use by providing vent pipes throughout the system.

30.3.1.9 Foul air exhaust
Each vent terminal shall extend to the outer air and be so installed as to minimize the possibilities of clogging and the return of foul air to the building, as it conveys potentially noxious or explosive gases to the outside atmosphere. All vent pipes shall be provided with a cowl.

30.3.1.10 Testing
The plumbing system shall be subjected to required tests to effectively disclose all leaks and defects in the work or the material.

30.3.1.11 Exclusion from plumbing system
No substance that will clog or accentuate clogging of pipes, produce explosive mixtures, destroy the pipes or their joints, or interfere unduly with the sewage-disposal process shall be allowed to enter the drainage system.

30.3.1.12 Light and ventilation
Wherever water closet or similar fixture shall be located in a room or compartment, it should be properly lighted and ventilated.

30.3.1.13 Individual sewage disposal systems
If water closets or other plumbing fixtures are installed in buildings where connection to public sewer is not possible, suitable provision shall be made for acceptable treatment and disposal.

30.3.1.14 Maintenance
Plumbing systems shall be maintained in a safe and serviceable condition.

30.3.1.15 Accessibility
All plumbing fixtures shall be so installed with regard to spacing as to be accessible for their intended use and for cleaning. All doors, windows and any other device needing access
within the toilet shall be so located that they have proper access.

30.3.1.16 Fixture for the disabled
Special toilet fixtures shall be provided for the disabled with required fixtures and devices.

30.3.1.17 Structural safety
Plumbing system shall be installed with due regard to preservation of the structural members and prevention of damage to walls and other surfaces.

30.3.1.18 Protection of ground and surface water
Sewage or other waste shall not be discharged into surface or sub-surface water without acceptable form of treatment.

30.3.2 Water supply connection

30.3.2.1 Application for obtaining supply connection
Every consumer, requiring a new supply of water or any extension or alteration to the existing supply shall apply in writing in the prescribed form (see Annex A) to the Authority.

30.3.2.2 Bulk supply
In the case of large housing estates or where new services are so situated that it will be necessary for the Water Supply Company to lay new mains or extend an existing main, full information about the proposed housing scheme shall be furnished to the Water Supply Company; information shall also be given regarding their phased requirements of water supply with full justification. Such information shall include site plans, showing the layout of roads, footpaths, building and boundaries and indicating there on the finished line and level of the roads or footpaths and water supply lines and appurtenances.

30.3.3 Drainage and sanitation

30.3.3.1 Preparation and submission of plan
No person shall install or carry out any water-borne sanitary installation or drainage installation or any works in connection with any existing or new buildings or any other premises without obtaining the previous sanction of the Authority. The owner shall make an application in the prescribed form (see Annex C) to the Authority to carry out such a work.

30.3.3.2 Site plan
A site plan of the premises on which the building is to be situated or any such work is to be carried out shall be prepared drawn to a scale not smaller than 1:500. The site plan of the building premises shall show:

a) the adjoining plots and streets with their names;
b) the position of the municipal sewer and the direction of flow in it;
c) the invert level of the municipal sewer, the road level, and the connection level of the proposed drain connecting the building in relation to the sewer;
d) the angle at which the drain from the building joints the sewer; and
e) the alignment, sizes and gradients of all drains and also of surface drains, if any.

A separate site plan is not necessary if the necessary particulars to be shown in such a site plan are already shown in the drainage plan.

30.3.3.3 Drainage plan
The application to the Water Supply Company shall be accompanied by a drainage plan drawn to a scale of not smaller than 1:100 and furnished along with the building plan. The plans shall show the following:

a) Every floor of the building in which the pipes or drains are to be used;
b) The position, forms, level and arrangement of the various parts of such building, including the roof thereof;
c) All new drains as proposed with their sizes and gradients;
d) Invert levels of the proposed drains with corresponding ground levels;
e) The position of every manhole, gully, soil and waste pipe, ventilating pipe, rain
water pipe, water-closet, urinal, latrine, bath, lavatory, sink, trap or other appliances in the premises proposed to be connected to any drain and the following colours are recommended for indicating sewers, waste water pipes, rainwater pipes an existing work.

<table>
<thead>
<tr>
<th>Description of Work</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewers</td>
<td>Red</td>
</tr>
<tr>
<td>Waste water pipes</td>
<td>Blue</td>
</tr>
<tr>
<td>Existing work</td>
<td>Black</td>
</tr>
</tbody>
</table>

f) The position of refuse chute, inlet hopper and collection chamber.

30.3.3.1 In the case of an alteration or addition to an existing building, this clause shall be deemed to be satisfied if the plans as furnished convey sufficient information for the proposals to be readily identified with previous sanctioned plans and provided the locations of tanks and other fittings are consistent with the structural safety of the building.

30.3.3.2 The plans for the building drainage shall in every case be accompanied by specifications for the various items of work involved. This information shall be supplied in the prescribed from given in Annex D.

30.3.3.4 In respect of open drains, cross-clauseal details shall be prepared to a scale not smaller than 1:50, showing the ground and invert levels and any arrangement already existing or proposed for the inclusion of any or exclusion of all storm water from the sewers.

30.3.5 Completion certificate

At the completion of the plumbing installation work, the licensed plumber shall give a completion certificate.

30.3.4.1 Execution of work

The work which is required to be carried out under the provisions of this Clause, shall be executed only by a licensed plumber under the control of the Engineering Council and shall be responsible to carry out all lawful directions given by the Engineering Council. No individual shall engage in the business of plumbing unless so licensed under the provisions of this Clause.

30.3.4.1.1 No individual, firm, partnership or corporation shall engage in the business of installing, repairing or altering plumbing unless the plumbing work performed in the course of such business is under the direct supervision of a licensed plumber.

30.3.4.2 Examination and certification

The Engineering Council shall establish standards and procedure for the qualification, examination and licensing of plumbers and shall issue licences to such persons who meet the qualifications thereof and successfully pass the examination.

30.3.4.3 For guidelines for registration of plumbers including the minimum standards for qualifications for the grant of licences, reference may be made to good practice.

30.4 Water supply

30.4.1 Water supply requirements for buildings

30.4.1.1 Water supply for residences

A minimum of 70 to 100 litres per head per day may be considered adequate for domestic needs of urban communities, apart from non-domestic needs as flushing requirements. As a general rule the following rates per capita per day may be considered minimum for domestic and non-domestic needs:

a) For communities with population up to 20000 and without flushing system:

1) water supply through standpost 40 lphd,( min.)
2) water supply through house service connection 70 to 100 lphd

b) For communities with population 2000 to 100000 together with full flushing system 100 to 150 lphd

c) For communities with population above 100000 together with full flushing system 150 to 200 lphd

Note: The value of water supply given as 150 to 200 litres per head per day (lphd) maybe reduced to 135 lphd for houses for Lower income groups (LIG) and Economically weaker clause of society(EWS), depending upon prevailing conditions.
30.4.1.1 Out of the 150 to 200 lphd, 45 lphd may be taken for flushing requirements and the remaining quantity for other domestic purposes.

30.4.1.2 Water supply for buildings other than residences

Minimum requirements for water supply for buildings other than residences shall be in accordance with Table 1.

30.4.1.3 Water supply requirements of traffic terminal stations

The water supply requirements of traffic terminal stations (railway stations, bus stations, harbours, airports, etc.) include provisions for waiting rooms and waiting halls. They do not, however, include requirements for retiring rooms. Requirements of water supply for traffic terminal stations shall be according to Table 2.

30.4.1.4 Water supply for firefighting purposes

30.4.1.4.1 The Authority shall make provision to meet the water supply requirements for firefighting in the city/area, depending on the population density and types of occupancy.

30.4.1.4.2 Provision shall be made by the owner of the building for water supply requirements for firefighting purposes within the building, depending upon the height and occupancy of the building.

---

**Table 1 Water Requirements for Buildings Other than Residences (Clause 4.1.2)**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Type of Building</th>
<th>Consumption per Day, litres</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>i)</td>
<td>Factories where both rooms are required to be provided</td>
<td>45 per head</td>
</tr>
<tr>
<td>ii)</td>
<td>Factories where no bath rooms are required to be provided</td>
<td>30 per head</td>
</tr>
</tbody>
</table>
| iii)  | Hospital (including laundry):  
| a) Number of beds not exceeding 100 | 340 per head |
| b) Number of beds exceeding 100 | 450 per head |
| iv)   | Nurses’ homes and medical quarters | 153 per head |
| v)    | Hostels | 153 per head |
| vi)   | Hotel (up to 4 star) | 190 per head |
| vii)  | Hotel (5 Star and above) | 320 per head |
| viii) | Offices | 45 per head |
| ix)   | Restaurants | 70 per seat |
| x)    | Common, concert halls and theatres | 15 per seat |
| xi)   | Schools:  
| a) Day schools | 45 per head |
| b) Boarding schools | 135 per head |

**Table 2 Water Supply Requirements for Traffic Terminal Stations (Clause 4.1.3)**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Nature of Station/TERMINAL</th>
<th>Water Supply Facilities are Provided</th>
<th>Water Supply Facilities are not Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>i)</td>
<td>Intermediate stations (excluding mall and express stops)</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>ii)</td>
<td>Junction stations and intermediate stations where mall or express stoppage is provided</td>
<td>70</td>
<td>45</td>
</tr>
<tr>
<td>iii)</td>
<td>Terminal stations</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>iv)</td>
<td>International and domestic airports</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

**Notes:**
1. The average number of passengers handled by the station daily, due consideration may be given to the staff and vendors likely to use the facilities.
2. Consideration should be given for seasonal average peak requirements.

30.4.1.4.3 The requirements regarding water supply in storage tanks, capacity of fuel pumps, arrangements of wet riser-cum-downcomer and wet riser installations for buildings above 15 m in height, depends upon the occupancy use.

30.4.2 Water sources and quality

30.4.2.1 The quality of water to be used for drinking shall be as per good practices.

30.4.2.2 For purposes other than drinking, water if supplied separately, shall be absolutely safe from bacteriological contamination so as to ensure that there is no danger to the health of the users due to such contaminants.

30.4.2.3 Waste water reclamation

Treated sewage or other waste water of the community may be utilized for non-domestic purposes such as water for cooling, flushing, lawns, parks, firefighting and for certain industrial purposes after giving the necessary treatment to suit the nature of the use. This supply system shall be allowed in residences only if proper provision is made to avoid any cross connection of this treated waste water with domestic water supply system.

30.4.2.4 Whenever a building is used after long intervals, the water quality of the stored water must be checked so as to ensure that the water is safe for use as per water quality requirements specified in this Code.
30.4.2.5 In making assessment of water supply requirements of large complexes, the future occupant load shall be kept in view.

30.4.2.6 The water may be stored either in overhead tanks (OHT) and/or underground tanks (UGT).

30.4.3 Materials used

Reservoirs and tanks for the reception and storage of water shall be constructed of reinforced concrete, brick masonry, ferrocement precast, mild steel, stainless steel or plastic.

30.4.3.1 Each tank shall be provided with the following:

a) Manholes — Adequate number of manholes for access and repair. The manholes shall be made of corrosion resistant material (for example, cast iron, reinforced cement concrete, steel fibre reinforced concrete, galvanized steel, high density polyethylene, fibre glass reinforced plastic or such other materials acceptable to the Authority). Manholes shall be provided with locking arrangement to avoid misuse and tampering.

b) Catch rings and ladders — Tanks higher than 900mm deep shall be provided with corrosion resistant catch rings, steps or ladders according to the depth to enable a person to reach the bottom of the tank.

c) Overflow pipe — Each tank shall be provided with an overflow pipe terminating above the ground/terrace level to act as a ‘Warning Pipe’ to indicate overflow conditions. The size of the overflow pipe shall be adequate to accept the flow. Normally the overflow pipe size shall be one size higher than the inlet pipe. When the inlet pipe diameter is large, two or more overflow pipes of equivalent cross-clause may be provided.

d) Vent pipes — Tanks larger than 5000l capacity shall be provided with vent pipes to prevent development pressure in the tank which might result in NO FLOW condition or inward collapse of the tank.

e) Scour pipe — Each tank shall be provided with a scour pipe with an accessible valve for emptying the tank.

f) Connection of overflow and scour pipe— Under no circumstances shall tank overflow and scour pipe be connected to any drain, gully trap or manhole to prevent back flow an contamination of the water. All such connections shall be discharged over a grating with an air gap of 50 mm. All overflow and vent pipes shall be provided with a mosquito proof brass grating to prevent ingress of mosquitoes, vermin and other insects.

g) The top slab of the tank must be suitably sloped away from its, centre for proper drainage of the rainwater.

h) Tanks on terraces and above ground shall be supported by appropriate structural members so as to transfer the load of the tank and the water directly on the structural members of the building.

30.4.3.2 Every storage tank shall be easily accessible and placed in such a position as to enable thorough inspection and cleaning to be carried out. If the storage capacity required is more than 5000l, it is advantageous to arrange it in a series of tanks so interconnected that each tank can be isolated for cleaning and inspection without interfering with the supply of water. In large storage tanks, the outlet shall be at the end opposite the inlet to avoid stagnation of the water.

30.4.3.3 The outlet pipe shall be fixed 50 mm to 75 mm above the bottom of the tank and fitted with a strainer, preferably of brass.

30.4.3.4 In the case of underground storage tanks, the design of the tank shall be such as to provide for the draining of the tank when necessary and water shall not be allowed to collect around the tank. The underground tanks should not be located in low lying areas or near any public or private sewer, septic tank, leaching pool or soakage pit to prevent any contamination. The overflow of the tank should be well above (preferably 600 mm) the external surface level and terminate as a warning pipe with a mosquito proof grating. Care must be taken to prevent the backflow of local surface water into the tank in case of local flooding. Otherwise the overflow must be terminated in a safer manner as per the site conditions. For tanks with at least one side
exposed to a basement, it is safer to discharge the overflow into the basement level.

The tank top slab shall also be designed to carry the load due to fire tender movement where anticipated as in the case of an extended basement. There should be no common wall between the tanks storing safe water and tanks storing water from unsafe sources.

30.4.3.5 In case of overhead tanks, the bottom of the tanks shall be placed clear off the terrace slab such that the elevation difference between the outlet pipe of the tank and the highest fixture at the top floor of the building is a minimum of 2m, which shall also prevent leakage into the structural slab. In tall buildings, the top of the tank shall be provided with the safe ladder or staircase. The top slab shall be provided with railing or a parapet wall.

30.4.3.6 For jointing steel pipe to a storage tank, the end of the pipe shall be screwed, passed through a hole in the tank and secured by back nuts, both inside and outside. The pipe end shall be flush with the face of the inside back nut. For jointing copper pipe to steel or copper tank, a connector of non-ferrous material shall be used. The connector shall have a shoulder to bear on the outside of the tank and shall be secured by a back nut inside.

30.4.3.7 The quantity of water to be stored shall be calculated taking into account the following factors:

a) hours of supply at sufficiently high pressure to fill up the overhead storage tanks;

b) frequency of replenishment of overhead tanks, during the 24 h;

c) rate and regularity of supply; and

d) consequences of exhausting storage particularly in case of public buildings like hospitals.

If the water supply is intermittent and the hours of supply are irregular, it is desirable to have a minimum storage of half a day's supply for overhead tanks. For additional requirement of water storage for firefighting purposes, good practices should be adhered to.

Note: General guidelines for calculation of capacity of these storage tanks are as follows:

a) In case only OHT is provided, it may be taken as 33.3 to 50 percent of one day's requirement;

b) In case only UGT is provided, it may be taken as 50 to 150 percent of one day's requirement; and

c) In case combined storage is provided, it may be taken as 66.6 percent UGT and 33.4 percent OHT of one day's requirement.

30.4.3.8 When only one communication pipe is provided for water supply to a building, it is not necessary to have separate storage for flushing and sanitary purposes for health reasons. In such cases, when only one storage tank has been provided, tapping of water maybe done at two different levels (the lower tapping for flushing) so that a part of the water will be exclusively available for flushing purposes.

30.4.4 Materials, fittings and appliances

30.4.4.1 Standards for materials, fittings and appliances

All materials, water fittings and appliances shall conform to the relevant Parts of this Code.

30.4.4.2 Materials for pipes

Pipes may be of any of the following materials:

a) ductile iron;

b) steel (internally lined or coated with bitumen or a bituminous composition, and out-coated with cement concrete or mortar, where necessary);

c) reinforced concrete;

d) prestressed concrete;

e) copper;

f) brass;

g) wrought iron;

h) polyethylene;

i) unplasticized PVC;

j) chlorinated PVC; or

k) stainless steel.
30.4.4.2.1 The material chosen shall be resistant to corrosion, both inside and outside or shall be suitably protected against corrosion.

30.4.4.2 Polyethylene and unplasticized PVC pipes shall not be installed near hot water pipes or near any other heat sources. For temperature limitations in the use of polyethylene and unplasticized PVC pipes to convey water, reference may be made to good practice.

### Table 3 Fixture Unit for Different Types of Fixtures with Inlet Pipe Diameter

(Clause 4.6.3.1)

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Type of Fixture</th>
<th>Fixture Unit FU</th>
<th>Minimum Normal Size of Fixture Branch, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>i)</td>
<td>Ablution tap</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>ii)</td>
<td>Bath tube supply by spout</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Shower over tub does not add to the load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii)</td>
<td>Shower stall domestic</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>iv)</td>
<td>Shower in groups per head</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>v)</td>
<td>Wash basin domestic use</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>vi)</td>
<td>Wash basin public use</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>vii)</td>
<td>Wash basin surgical</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>viii)</td>
<td>Scrub station in hospitals per outlet</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>ix)</td>
<td>Drinking water fountain/water cooler</td>
<td>0.5</td>
<td>15</td>
</tr>
<tr>
<td>x)</td>
<td>Water-closet with cistern (single/double flush)</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>xi)</td>
<td>Water-closet with flush or magic eye operated valve</td>
<td>8</td>
<td>25/32</td>
</tr>
<tr>
<td>xii)</td>
<td>Urinals with auto flushing cisterns</td>
<td>4</td>
<td>15/20</td>
</tr>
<tr>
<td>xiii)</td>
<td>Urinals with flush or magic eye operated valve</td>
<td>2</td>
<td>15/20</td>
</tr>
<tr>
<td>xiv)</td>
<td>Kitchen sink (domestic use)</td>
<td>2</td>
<td>15/20</td>
</tr>
<tr>
<td>xv)</td>
<td>Washing machine</td>
<td>3</td>
<td>15/20</td>
</tr>
</tbody>
</table>

30.4.5 Design of distribution systems

30.4.5.1 General

All buildings shall conform to the general requirements given in Clause 30.3.

30.4.5.2 Discharge computation

30.4.5.2.1 Design of consumer’s pipes based on fixture units

The design of the consumers’ pipes or the supply pipe to the fixtures is based on:

a) the number and kind of fixtures installed;  
b) the fixture unit flow rate; and  
c) the probable simultaneous use of these fixtures.

The rates at which water is desirably drawn into different types of fixtures are known. These rates become whole numbers of small size when they are expressed in fixture unit.

The fixture units for different sanitary appliances or groups of appliances are given in Table 3 and Table 4.

30.4.5.2.2 Probable simultaneous demand

### Table 4 Fixture Unit for Different Types of Fixtures Based on Pipes of Trap Diameter

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Drain of Trap Outlet Diameter mm</th>
<th>Fixture Unit FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>i)</td>
<td>32 or smaller</td>
<td>1</td>
</tr>
<tr>
<td>ii)</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>iii)</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>iv)</td>
<td>65</td>
<td>4</td>
</tr>
<tr>
<td>v)</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>vi)</td>
<td>100</td>
<td>6</td>
</tr>
</tbody>
</table>

1169
Note: Before using the above figures check the actual fl from the outlets of special equipment, for example, small period high discharges, for example, from washing machines, boiler downs, filter backwash and water tank emptying operations.
30.4.5.3 Pipe size computation
Commercially available standard sizes of pipes are only to be used against the sizes arrived at by actual design.

30.4.7 General requirements for pipe work

30.4.7.1 Service pipes

a) Every premises that is supplied with water by the Water Supply Company shall have its own separate communication pipe. In the case of a group or block of premises belonging to the same owner, the same communication pipe may supply water to more than one premises with the prior permission of the Water Supply Company.
b) The communication pipe between the water main and the stop-cock at the boundary of the premises shall be laid by the Water Supply Company.

30.4.7.2 Consumer pipes

a) No consumer pipe shall be laid in the premises to connect the communication pipe without the approval of the Water Supply Company.
b) The consumer pipe within the premises shall be laid underground with a suitable cover to safeguard against damage from traffic and extremes of weather.
c) To control the branch pipe to each separately occupied part of a building supplied by a common service pipe, a stop valve shall be fixed to minimize the interruption of the supply during repairs. All such stop valves shall be fixed in accessible positions and properly protected. To supply water for drinking or for culinary purposes, direct taps shall be provided on the branch pipes connected directly to the consumer pipe. In the case of multi-storeyed buildings, downtake taps shall be supplied from overhead tanks.
d) Pumps shall not be allowed on the service pipe, as they cause a drop in pressure on the suction side, thereby affecting the supply to the adjoining properties. In cases where pumping is required, a properly protected storage tank of adequate capacity shall be provided to feed the pump.
e) Consumer pipes shall be so designed as to reduce the production and transmission of noise as much as possible.
f) Consumer pipes in roof spaces and unventilated air spaces under floors or in basements shall be protected against corrosion.
g) Consumer pipes shall be so located that they are not unduly exposed to accidental damage and shall be fixed in such positions as to facilitate cleaning and avoid accumulations of dirt.

All consumer pipes shall be so laid as to permit expansion and contraction or other movements.

30.4.7.3 Prohibited connections

a) A service pipe shall not be connected into any distribution pipe; such connection may permit the backflow of water from a cistern into the service pipe, in certain circumstances, with consequent danger of contamination and depletion of storage capacity. It might also result in pipes and fittings being subjected to a pressure higher than that for which they are designed, and in flooding from overflowing cisterns.
b) No pipe for conveyance or in connection with water supplied by the Authority shall communicate with any other receptacle used or capable of being used for conveyance other than water supplied by the Authority.
c) Where storage tanks are provided, no person shall connect or be permitted to connect any service pipe with any distributing pipe.
d) No service or supply pipe shall be connected directly to any water-closet or a urinal. All such supplies shall be from flushing cisterns which shall be supplied from storage tank.
e) No service or supply pipe shall be connected directly to any hot water system or to any other apparatus used for
30.4.8 Jointing of pipes

30.4.8.1 Cast iron pipes

Jointing may be done by any of the following methods:

a) spigot and socket joints; or
b) flanged joints in accordance with good practice.

The lead shall conform to the accepted standards.

30.4.8.2 Steel pipes

Plain-ended steel pipes may be jointed by welding. Electrically welded steel pipes shall be jointed in accordance with good practice.

30.4.8.3 Wrought iron and steel screwed pipes

Screwed wrought iron or steel piping maybe jointed with screwed and socketed joints. Care shall be taken to remove any burr from the end of the pipes after screwing. A jointing compound approved by the Authority and containing no red lead composition shall be used. Screwed wrought iron or steel piping may also be jointed with screwed flanges.

30.4.8.4 Asbestos cement pipes

Asbestos cement pipes shall not be used.

30.4.8.5 Copper pipes

Copper pipes shall be jointed by an internal soldering joint, end-brazing joint or by use of compression fitting. The flux used shall be non-toxic and the solder used shall be lead free. The use of dezincification fittings shall be made in the case of jointing of copper pipe and steel pipe.

30.4.8.6 Concrete pipes

Concrete pipes shall be jointed in accordance with good practice.

30.4.8.7 Polyethylene and unplasticized PVC pipes

Polyethylene and unplasticized PVC pipes shall be jointed in accordance with good practice (i.e. welding by electrical fusion, use of jointing compounds and mechanical joints).

30.4.9 Backflow prevention

30.4.9.1 The installation shall be such that water delivered is not liable to become contaminated or that contamination of the public water supply does not occur.

30.4.9.2 The various types of piping and mechanical devices acceptable for backflow protection are:

a) barometric loop;
b) air gap;
c) atmosphere vacuum breaker;
d) pressure vacuum breaker;
e) double check valve; and
f) reduced pressure backflow device.

30.4.9.3 The installation shall not adversely affect drinking water:

a) by materials in contact with the water being unsuitable for the purpose;
b) as a result of backflow of water from water fittings, or water using appliances into pipework connected to mains or to other fittings and appliances;
c) by cross-connection between pipes conveying water supplied by the water undertaker with pipes conveying water from some other source; and
d) by stagnation, particularly at high temperatures.

30.4.9.4 No pump or similar apparatus, the purpose of which is to increase the pressure in or rate of flow from a supply pipe or any fitting or appliance shall be connected to a supply pipe.

The use of such a pump or similar apparatus is likely to lead to pressure reduction in the upstream pipe work which, if significant, increase the risk of backflow from other fittings.

30.4.9.5 The water shall not come in contact with unsuitable materials of construction.
30.4.9.6 No pipe or fitting shall be laid in, on or through land fill, refuse, an ashpit, sewer, drain, cesspool, refuse chute, or any manhole connected with them.

30.4.9.7 No pipe susceptible to deterioration by contact with any substance shall be laid or installed in a place where such deterioration is likely to occur. No pipe that is permeable to any contaminant shall be laid or installed in any position where permeation is likely to occur.

30.4.9.8 If a liquid (other than water) is used in any type of heating primary circuit, which transfers heat to water for domestic use, the liquid shall be non-toxic and noncorrosive.

30.4.9.9 A backflow prevention device shall be arranged or connected at or as near as practicable to each point of delivery and use of water. Appliances with built-in backflow prevention shall be capable of passing the test. All backflow prevention devices shall be installed so that they are accessible for examination, repair or replacement. Such devices shall be capable of being tested periodically by the Authority to ensure that the device is functioning efficiently and no backflow is occurring at any time.

30.4.10 Conveyance and distribution of water within the premises

30.4.10.1 The design of the pipe work shall be such that there is no possibility of backflow towards the source of supply from any cistern or appliance, whether by siphonage or otherwise. Reflux non-return valves shall not be relied upon to prevent such backflow.

30.4.10.2 Where a supply of less satisfactory water than wholesome water becomes inevitable as an alternative or is required to be mixed with the latter, it shall be delivered only into a cistern and by a pipe or fitting discharging into the air gap at a height above the top edge of the cistern equal to twice its nominal bore and in no case less than 150 mm. It is necessary to maintain a definite air gap in all appliances or taps used in water closets.

30.4.10.3 All pipe work shall be so designed, laid or fixed and maintained as to remain completely water-tight, thereby avoiding wastage, damage to property and the risk of contamination.

30.4.10.4 No water supply line shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith nor through any ash pit or manure pit or any material of such nature that is likely to cause undue deterioration of the pipe, except where it is unavoidable.

30.4.10.4.1 Where the laying of any pipe through corrosive soil or pervious material is unavoidable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means as approved by the Authority. Any existing piping or fitting laid or fixed, which does not comply with the above requirements, shall be removed immediately by the consumer and relaid by him in conformity with the above requirements and to the satisfaction of the Authority.

30.4.10.4.2 Where lines have to be laid in close proximity to electric cables or in corrosive soils, adequate precautions/protection should be taken to avoid corrosion.

30.4.10.5 Underground piping shall be laid at such a depth that it is unlikely to be damaged by traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided, special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

30.4.10.6 In designing and planning the layout of the pipe work, due attention shall be given to the maximum rate of discharge required, economy in labour and materials, protection against damage and corrosion, water hammer, protection from frost, if required, and to avoidance of airlocks, noise transmission and unsightly arrangement.

30.4.10.7 To reduce frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection at the joints, whether of the jointing materials or otherwise.
30.4.10.8 Change in diameter and in direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made which is likely to materially diminish or alter the cross-clause.

30.4.10.9 No boiler for generating steam or closed boilers of any description or any machinery shall be supplied direct from a service or supply pipe. Every such boiler or machinery shall be supplied from a feed cistern.

30.4.12 Hot water supply installations

30.4.12.1. Design consideration

30.4.12.1.1 General
The accepted method for, electric water heating practice for domestic purposes, shall be the instantaneous electric heating.

30.4.12.10 Cold water supply to heaters

30.4.12.10.1 A storage water heater (pressure type) shall be fed from a cold water storage tank and under no circumstances connected directly to the water main, except the type which incorporates a feed tank with ball valves and overflow pipe arrangement (cistern type heaters) or non-pressure type heaters.

30.4.12.10.2 Storage cisterns

30.4.12.10.2.1 The storage capacity of a cold water tank shall be at least twice the capacity of the hot water heater. The capacity of the storage tank may, however, be 1.5 times when the number of heaters connected to one common tank exceeds 10.

30.4.12.10.2.2 The storage tank for supply of cold water to hot water heaters shall be separate, if practicable. In the case of a common tank which also supplies cold water to the fixtures, this cold water supply connection shall be so arranged that 50 percent of the net capacity, worked out as in Clause 30.4.12.10.2.1, shall be available for supply to the hot water heaters.

30.4.12.10.2.3 In the case of multi-storeyed buildings where a common overhead tank over the stair/lift well is generally installed, it is advisable to have one or more local tanks for supply to the hot water heaters. This arrangement shall help in reducing the length of the vent pipes (see Fig. 9).

30.4.12.10.2.4 In tall multi-storeyed buildings where the static pressure increases with the height, the total static pressure on the hot water heaters on the lowest floor shall not exceed the rated working pressure of the hot water heater installed. Should the height of the building so require, additional tanks shall be provided on the intermediate floors to restrict the static head to permissible limits (see Fig. 10).

30.4.12.10.2.5 As an alternative to the arrangements stated in Clauses 30.4.12.10.2.3 and 30.4.12.10.2.4, an individual storage tank in each flat may be provided for supply to hot water heaters (see Fig. 11).

30.4.12.11 Cold water feed

30.4.12.11.1 The feed pipe connecting cold water tank with the hot water heater shall not be of less than 20 mm bore and it shall leave the cold water tank at a point not less than 50 mm above the bottom of the tank and shall connect into the hot water heater near its bottom. The feed pipe shall not deliver cold water to any other connection, but into the hot water cylinders only.

30.4.12.11.2 In the case of multi-storeyed buildings, a common cold water feed pipe may be installed, but each hot water heater shall be provided with a check valve (horizontal type check valve shall be preferred to vertical type for easy maintenance).

30.4.12.11.3 Care shall be taken in installing the piping to prevent airlocks in the piping and negative pressure in the hot water heater. Cold water feed pipe shall not be cross-connected with any other source of supply under pressure (see Fig. 9).

30.4.12.12 Hot water piping
30.4.12.1 Expansion pipe or vent pipe.

30.4.12.1.1 Each pressure type hot water heater or cylinder shall be provided with a vent pipe of not less than 20mm bore. The vent pipe shall rise above the water line of the cold water tank by at least 150mm plus 10mm for every 300mm height of the waterline above the bottom of the heater. The vent shall discharge at a level higher than the cold water tank and preferably in the cold water tank supplying the hot water heaters. Care shall be taken to ensure that any accidental discharge from the vent does not hurt or scald any passerby or persons in the vicinity.

30.4.12.1.2 The vent pipe shall be connected to the highest point of the heater vessel and it shall not project downwards inside it, as otherwise air maybe trapped inside, resulting in surging and consequent noises.

30.4.12.1.3 At no point, after leaving the vessel, shall the vent pipe dip below the level of its connection with the vessel.

30.4.12.1.4 A vent pipe may, however, be used for supply of hot water to any point between the cold water tank and the hot water heaters.

30.4.12.1.5 The vent pipe shall not be provided with any valve or check valves.

30.4.12.2 Hot water heaters

30.4.12.2.1 The common hot water delivery pipe shall leave the hot water heater near its top and shall be of not less than 20 mm bore generally, and not less than 25 mm bore if hot water taps are installed on the same floor as that on which the hot water heater is situated.

30.4.12.2.2 Hot water taps shall be of such design as would cause the minimum friction. Alternatively, oversized tap may be provided, such as a 20 mm tap on a 15 mm pipe.

30.4.12.2.3 The hot water distributing system shall be so designed as to ensure that the time lag between opening of the draw-off taps and discharge of hot water is reduced to the minimum to avoid wastage of an undue amount of water which may have cooled while standing in the pipes when the taps are closed. With this end in view, a secondary circulation system with flow and return pipes from the hot water tank shall be used where justified. Whether such a system is used or not, the length of pipe to a hot water draw-off tap, measured along the pipe from the tap to the hot water tank or the secondary circulation pipe, shall not exceed the lengths given in Table 8.

<table>
<thead>
<tr>
<th>Table 8: Maximum permissible lengths of hot water draw-off pipes (Clause 30.4.12.2.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Largest internal diameter of pipe Length(m)</td>
</tr>
<tr>
<td>i) Not exceeding 20 mm</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>ii) Exceeding 20 mm but not exceeding 25 mm</td>
</tr>
<tr>
<td>7.5</td>
</tr>
<tr>
<td>iii) Exceeding 25 mm</td>
</tr>
<tr>
<td>3.0</td>
</tr>
</tbody>
</table>

Note: In the case of a composite pipe of different diameters, the largest diameter is to be taken into consideration for the purpose of this table.

30.4.12.2.4 Wherever mixing of hot and cold water is done by a mixing fitting, that is, hot and cold stop-cocks deliver to a common outlet of mixed water (as in showers, basin or bath supply fittings), the pressure in the cold and hot water systemsshall beequal

30.4.12.13.1 The quality and construction of the different types of hot water heaters shall be in accordance with good practice.

30.4.12.13.2 Typical arrangement of a water heater is shown in Fig. 12.

30.4.12.13.3 Requirements in regard to inspection and maintenance of hot water supply installations shall be in accordance with Clauses 9.6.4.14.1 to 9.6.4.14.4.

30.4.13.2.3 Electrical connection

For relevant provisions regarding general and safety requirements for household and similar electrical appliances, reference shall be made to GS 1009.
30.4.14 cleaning and disinfection of the supply system

30.4.14.1 Communication pipes, service pipes and pipes used for distribution of water for domestic purposes shall be thoroughly and efficiently disinfected before being taken into use and also after every major repair. The method of disinfection shall be subject to the approval of the Authority. The pipes shall also be periodically cleaned at intervals, depending upon the quality of water, communication pipes and the storage cisterns shall be thoroughly cleaned at least once every year in order to remove any suspended impurities that may have settled in the pipes or the tanks.

30.4.15 Water supply systems in high altitudes and/or sub-zero temperature regions

30.4.15.1 Pumping Installation
Pump and pumping machinery shall be housed inside well-insulated chambers. Where necessary, arrangements shall be made for heating the inside of pump houses. Pump houses, as far as possible, should be built directly above the water intake structures.

30.4.15.2 Transmission and Distribution
For the efficient operation and design of transmission and distribution work, the available heat in the water shall be economically utilized and controlled. If the heat which is naturally present in water is made equate to satisfy heat losses from the system, the water shall be warmed. If found unsuitable for drinking purposes, such water may be used for heating purposes. Heat losses shall be reduced by insulation, if necessary. Any material that will catch, absorb or hold moisture shall not be used for insulation purposes. Adequate number of break pressure water tanks and air release valves shall be provided in the distribution system.

30.4.15.2.1 Materials for pipes
Distribution pipes shall be made of any of the following materials.

a) high density polyethylene pipes;
b) galvanized iron pipes;
c) cast iron pipes; and
d) unplasticized PVC pipes.

30.5. PRELIMINARY DATA FOR DESIGN

30.5.1 General
Before the drainage system for a building or group of buildings is designed and constructed, accurate information regarding the site conditions is essential. This information may vary with the individual scheme but shall, in general, be covered by the following:

a) Site plan (see Clause 30.3.3.2).
b) Drainage plan (see Clause 30.3.3.3).
c) Use — A description of the use for which the building is intended and periods of occupation in order that peak discharges may be estimated.

a) Nature of Waste — While dealing with sewage from domestic premises, special problems under this head may not arise; however, note shall be taken of any possibility of trade effluents being discharged into the pipes at a future date.

b) Outlet Connection — The availability of sewers or other outlets.

c) Cover — The depth (below ground) of the proposed sewers and drains and the nature and weight of the traffic on the ground above them;

g) Sub-soil Condition:
1) The approximate level of the subsoil water, and any available records of flood levels shall be ascertained, as also the depth of the water table relative to all sewer connections, unless it is known to be considerably below the level of the latter.

2) Where work of any magnitude is to be undertaken, trial pits or boreholes shall be put in at intervals along the line of the proposed sewer or drain and the data there from tabulated, together with any information available from previous works carried out in the vicinity.
3) The positions of trial pits or boreholes shall be shown on the plans, together with clauses showing the strata found and the dates on which water levels are recorded.

h) Location of other services — The position, depth and size of all other pipes, mains, cables, or other services, in the vicinity of the proposed work, may be ascertained from the Authority, if necessary;

j) Reinstatement of surfaces — Information about the requirements of the highway authority is necessary where any part of the sewer or drain is to be taken under a highway. Those responsible for the sewer or drain shall be also responsible for the maintenance of the surface until permanently reinstated. The written consent of the highway authority to break up the surface and arrangement as to the charges thereof and the method and type of surface reinstatement shall always be obtained before any work is commenced.

30.5.2 Drainage into a public sewer
Where public sewerage is available, the following information is particularly necessary and may be obtained from the Authority:

a) the position of the public sewer or sewers in relation to the proposed buildings;

b) the invert level of the public sewer;

c) the system on which the public sewers are designed (combined, separate or partially separate), the lowest level at which connection may be made to it, and the Authority in which it is vested;

d) the material of construction and condition of the sewer if connection is not to be made by the Authority;

a) the extent to which surcharge in the sewer may influence the drainage scheme;

b) whether the connection to the public sewer is made, or any part of the drain laid, by the Authority, or whether the owner is responsible for this work; if the latter, whether the Authority imposes any special conditions;

c) whether an intercepting trap is required by the Authority on the drain near the boundary of the curtilage; and

d) where manholes are constructed under roads, the approval of the Highway Authority for the type of cover to be fitted shall be obtained.

30.5.3 Other methods of disposal of sewage

30.5.3.1 Where discharge into a public sewer is not possible, the drainage of the building shall be on a separate system. Foul water shall be disposed of by adequate treatment approved by the Authority on the site. The effluent from the plant shall be discharged into a natural watercourse or on the surface of the ground or disposed of by sub-soil dispersion preferably draining to a suitable outlet channel.

30.5.3.2 In the case of dilution into a natural stream course, the quality of the effluent shall conform to the requirements of the Authority controlling the prevention of pollution of streams.

30.5.3.3 In the case of sub-soil dispersion, the requirements of the Authority for water supply shall be observed to avoid any possible pollution of local water supplies or wells.

30.5.3.4 The general sub-soil water level and the subsoil conditions shall be ascertained, including the absorptive capacity of the soil.

30.5.3.5 A sub-soil dispersion is not desirable near a building or in such positions that the ground below the foundations is likely to be affected.

30.5.3.6 Where no other method of disposal is possible, foul water may be diverted to cesspools and arrangements made with the Authority for satisfactory periodical removal and conveyance to a disposal works.

30.5.3.7 Under the separate system, drainage of the building shall be done through septic tanks of different sizes or by stabilization ponds or by any other methods approved by the Authority. For detailed information on the design and construction of septic tanks and waste stabilization ponds, reference may be made to good practice.

30.5.4 Disposal of surface and sub-soil waters
All information which may influence the choice of methods of disposal of surface and/or sub-soil waters shall be obtained. In the absence of a surface water drainage system, and if practicable and permissible, disposal into a natural water-course or soakaway may be
adopted. The location and flood levels of the water course as also the requirements of the Authority controlling the river or the waterway shall be ascertained.

30.5.5 Planning and design considerations

30.5.5.1 General

Rain-water should preferably be dealt with separately from sewage and sullage. Sewage and sullage shall be connected to sewers. However, storm water from the courtyard may be connected to the sewer where it is not possible to drain otherwise; after obtaining permission of the Authority.

30.5.5.5 Drainage (soil, waste and ventilating) pipes

30.5.5.5.1 General considerations

30.5.5.5.1.1 Drainage pipes shall be kept clear of all other services. Provisions shall be made during the construction of the building for the entry of the drainage pipes. In most cases this may be done conveniently by building sleeves or conduit pipes into or under the structure in appropriate positions. This will facilitate the installation and maintenance of the services.

30.5.5.5.1.2 Horizontal drainage piping should be so routed as not to pass over any equipment or fixture where leakage from the line could possibly cause damage or contamination. Drainage piping shall never pass over switch-gear or other electrical equipment. If it is impossible to avoid these areas and piping must run in these locations, then a pan or drain tray should be installed below the pipe to collect any leakage or condensation. A drain line should run from this pan to a convenient floor drain or service sink.

30.5.5.5.1.3 All vertical soil, waste, ventilating and anti-siphonage pipes shall be covered on top with a copper or heavily galvanized iron wire dome or cast iron terminal guards. All cast iron pipes, which are to be painted periodically, shall be fixed to give a minimum clearance of 50mm from the finished surface of the wall by means of suitable clamps.

30.5.5.5.1.4 Drainage pipes shall be carried to a height above the buildings as specified for ventilating pipe (see Clause 30.5.5.4).

30.5.5.5.2 Soil pipes

A soil pipe, conveying to a drain, any solid or liquid filth, shall be circular and shall have a minimum diameter of 100 mm.

30.5.5.5.2.1 Except where it is impracticable, the soil pipe shall be situated outside the building or in suitably designed pipe shafts and shall be continued upwards without diminution of its diameter, and (except where it is unavoidable) without any bend or angle, to such a height and position as to afford, by means of its open end, a safe outlet for foul air. The position of the open end with its covering shall be such as to comply with the conditions set out in this Code relating to ventilating pipes. Even if the pipes are laid externally, the soil pipes shall not be permitted on a wall abutting a street unless the Authority is satisfied that it is unavoidable. Where shafts for pipes are provided, the cross-clauseal area of the shaft shall be suitable to allow free and unhampered access to the pipes and fittings proposed to be installed in the shaft. However, in no case shall the cross-clauseal area of the shaft be less than one square meter. All pipe shafts shall be provided with an access door at ground level and facilities for ventilation.

30.5.5.5.2.2 Soil pipes, whether inside or outside a building, shall not be connected to any rainwater pipe and there shall not be any trap in such a soil pipe or between it and any drain to which it is connected.

30.5.5.5.2.4 The soil pipe shall be provided with a heel rest bend which shall rest on sound footing, if terminating at firm ground level. When the stack is terminating at the ceiling (soffit) of a floor, the bend shall be provided with sufficient structural support to cater for the stack dead weight and the thrust developed from the falling soil/waste. Vertical stack shall be fixed at least 50 mm clear of the finished surface of the wall by means of suitable clamps of approved type.

30.5.5.8 Special wastes

30.5.5.8.1 General

Piping system for all special wastes should be separate and independent for each type of waste and should not be connected to the building drainage system. Other applicable provisions for installation of soil and waste pipe system shall however be followed.
30.5.5.8.2 Laboratory wastes
A study of the possible chemical, corrosive and toxic properties of wastes handled and disposed of in a laboratory need to be ascertained in advance. The relevant statutory rules and regulations regarding the method of disposal of strong and objectionable wastes shall be followed. All sinks, receptacles, traps, pipes, fittings and joints shall be of materials resistant to the liquids disposed of in the system. In laboratories for educational, research and medical institutions, handling mildly corrosive and toxic wastes, such wastes may be neutralized in chambers using appropriate neutralizing agents. The chamber shall be provided with chambers at inlet and outlet for collecting samples of the incoming and outgoing waste for monitoring its characteristics.

30.5.5.9 Grease traps
Grease traps shall be installed in buildings having oil and grease types of wastes. In principle the grease laden water is allowed to retain in a grease trap which enables any solids to be settled or separated for manual disposal. The retention time allows the incoming waste to cool and allow the grease to solidify. The clear waste is then allowed to discharge into the building’s drainage system.

30.5.5.14.5.1 Sewerage laying
The trenches for sewers shall be loosely filled with earth after laying sewers, since loose soil is a better insulator than compacted soil.

31.1 GENERAL

31.1.1 Scope

31.1.1.1 This clause covers the requirements for installation, operation and maintenance and also inspection of lifts (passenger lifts, goods lifts, hospital lifts, service lifts and dumb waiter) and escalators so as to ensure safe and satisfactory performance.

31.1.1.2 This clause gives information that should be exchanged among the architect, the consulting engineer and the lift/escalator manufacturer from the stage of planning to installation including maintenance.

Note: The provisions given in this Clause are primarily for electric traction lift; however, most of these provisions are also applicable to hydraulic lifts.

Consequently, sewers laid under traffic ways and other places where soil compaction may be expected are required to be given adequate insulation. Where feasible, sewers shall be so located that the trench line is not in shadow, when the sun is shining. Concrete, cast iron and stoneware pipes conduct heat relatively rapidly and as such should be adequately insulated.

30.5.5.14.5.4 Sewage treatment plants
Suitable design modifications for sedimentation, chemical and biological processes shall be applied to sewage treatment plants for satisfactory functioning.

30.5.8 Selection and installation of sanitary appliances
30.5.8.1 Selection, installation and maintenance of sanitary appliances shall be done in accordance with good practice.

PART 31: LIFT AND CONVEYING SYSTEMS

31.1 GENERAL

31.1.2 Definitions
For the purpose of this Clause, the following definitions shall apply.

AUTOMATIC RESCUE DEVICE
A device meant to bring a lift stuck between floors due to loss of power, to the nearest level and open the doors in order to allow trapped passengers to be evacuated. Such a device may use some form of internal auxiliary power source for such purpose, complying with all the safety requirements of a lift during normal run. The speed of travel is usually lower than the normal speed. In the case of manual doors on reaching the level, the device shall allow the door to be opened and in case of power operated doors the device shall automatically open the door.

BOTTOM CAR RUNBY: The distance between the car buffer striker plate and the striking surface of the car buffer when the car is in level with the bottom terminal landing.

BOTTOM COUNTERWEIGHT RUNBY: The distance between the counter weight buffer striker plate and the striking surface of the counterweight buffer when the car is in level with the top terminal landing.

BUFFER: A device designed to stop a descending car or counter weight beyond its normal limit of travel by storing or by absorbing and dissipating the kinetic energy of the car or counterweight.

OIL BUFFER: A buffer oil as a medium which absorbs and dissipates the kinetic energy of the descending car or counterweight.

OIL BUFFER STROKE: The oil displacing movement of the buffer plunger or piston, excluding the travel of the buffer plunger accelerating device.

SPRING BUFFER: A buffer which stores in a spring the kinetic energy of the descending car or counterweight.

SPRING BUFFER LOAD RATING: The load required to compress the spring by an amount equal to its stroke.

SPRING BUFFER STROKE: The distance, the contact end of the spring can move under a compressive load until the spring is compressed solid.

CALL INDICATOR: A visual and audible device in the car to indicate to the attendant the lift landings from which calls have been made.

CAR BODYWORK: The enclosing bodywork of the lift car which comprises the sides and roof and is built upon the car platform.

CAR DOOR ELECTRIC CONTACT: An electric device, the function of which is to prevent operation of the driving machine by the normal operating device unless the car door is in the closed position.

CAR FRAME: The supporting frame or sling to which the platform of the lift car, its safety gear, guide shoes and suspension ropes are attached.

CAR PLATFORM: The part of the lift car which forms the floor and directly supports the load.

BOTTOM CAR CLEARANCE: The clear vertical distance from the pit floor to the lowest structural or mechanical part, equipment or device installed beneath the car platform aprons or guards located within 300mm, measured horizontally from the sides of the car platform when the car rests on its fully compressed buffers.

TOP CAR CLEARANCE: The shortest vertical distance between the top of the car crosshead, or between the top of the car where no crosshead is provided, and the nearest part of the overhead structure or any other obstruction when the car floor is level with the top terminal landing.

TOP COUNTERWEIGHT CLEARANCE: The shortest vertical distance between any part of the counterweight structure and the nearest part of the overhead structure or any other obstruction when the car floor is level with the bottom terminal landing.

CONTROL: The system governing starting, stopping, direction of motion, acceleration, speed and retardation of moving member.

SINGLE SPEED ALTERNATING CURRENT CONTROL: A control for a driving machine induction motor which is arranged to run at a single speed.

TWO-SPEED ALTERNATING CURRENT CONTROL: A control for a two-speed driving machine induction motor which is arranged to run at two different synchronous speeds either by pole changing of a single motor or by two different armatures.

RHEOSTATIC CONTROL: A system of control which is accomplished by varying resistance or...
reactance or both in the armature or field circuit
or both of the driving machine motor.

**VARIABLE VOLTAGE MOTOR CONTROL**
**GENERATOR FIELD CONTROL):** A system of
control which is accomplished by the use of an
individual generator for each lift wherein the
voltage applied to the driving machine motor is
adjusted by varying the strength and direction of
the generator field.

**ELECTRONIC DEVICES:** A system of control
which is accomplished by the use of electronic
devices for driving the lift motor at variable
speed.

**ALTERNATING CURRENT VARIABLE
VOLTAGE (ACVV) CONTROL:** A system of
speed control which is accomplished by varying
the driving and braking torque by way of voltage
variation of the power supply to the driving
machine induction motor.

**ALTERNATING CURRENT VARIABLE
VOLTAGE VARIABLE FREQUENCY
(ACVVVF):** A system of speed control which is
accomplished by varying the voltage and
frequency of the power supply to the driving
machine induction motor.

**SOLID-STATE D.C. VARIABLE VOLTAGE
CONTROL:** A solid-state system of speed
control which is accomplished by varying the
voltage and direction of the power supply to the
armature of driving machine d.c. motor.

**COUNTERWEIGHT:** A weight or series of
weights to counter-balance the weight of the lift
car and part of the rated load.

**DEFLECTOR SHEAVE:** An idler pulley used to
change the direction of a rope lead.

**DOOR**

**DOOR, CENTRE OPENING SLIDING:** A door
which slides horizontally and consists of two or
more panels which open form the centre and are
usually so interconnected that they move
simultaneously.

**DOOR, MID-BAR COLLAPSIBLE:** A collapsible
doors with vertical bars mounted between the
normal vertical members.

**DOOR, MULTI-PANEL:** A door arrangement
whereby more than one panel is used such that
the panels are connected together and can slide
over one another by which means the clear
opening can be maximized for a given shaft
width. Multi-panels are used in centre opening
and two speed sliding doors.

**DOOR, SINGLE SLIDE:** A single panel door
which slides horizontally.

**DOOR, TWO SPEED SLIDING:** A door which
slides horizontally and consists of two or more
panels, one of which moves at twice the speed of
the other.

**DOOR, VERTICAL BI-PARTING:** A door which
slides vertically and consists of two panels or
sets of panels that move away from each other
to open and are so interconnected that they
move simultaneously.

**DOOR, VERTICAL LIFTING:** A single panel
door, which slides in the same plane vertically
up to open.

**DOOR, SWING:** A swinging type single panel
door which is opened manually and closed by
means of a door closer when released.

**DOOR CLOSER:** A device which automatically
closes a manually opened door.

**DOOR OPERATOR:** A power-operated device
for opening and closing doors.

**DUMB WAITERS: A lift with a car which moves
in guides in a vertical direction; has a net floor
area of 1 m², total inside height of 1.2m, whether
or not provided with fixed or removable shelves;
has a capacity not exceeding 250 kg and is
exclusively used for carrying materials and shall
not carry any person.

**ELECTRICAL AND MECHANICAL
INTERLOCK:** A device provided to prevent
simultaneous operation of both up and down
relays.

**ELECTRO-MECHANICAL LOCK:** A device
which combines in one unit, electrical contact
and a mechanical lock jointly used for the
landing and/or car doors.

**EMERGENCY STOP PUSH OR SWITCH:** A
push button or switch provided inside the car
designed to open the control circuit to cause the lift car to stop during emergency.

**ESCALATOR:** A power driven, inclined, continuous stairway used for raising or lowering passengers.

**ESCALATOR INSTALLATIONS:** It includes the escalator, the track, the trusses or girders, the balustrading, the step treads and landing and all chains, wires and machinery directly connected with the operation of the escalator.

**ESCALATOR LANDING:** The portion of the building or structure which is used to receive or discharge passengers into or from an escalator.

**ESCALATOR LANDING ZONE:** A space extending from a horizontal plane 40 cm below a landing to a plane 40 cm above the landing.

**ESCALATOR MACHINE:** The mechanism and other equipment in connection therewith used for moving the escalator.

**FLOOR LEVELLING SWITCH:** A switch for bringing the car to level at slow speed in case of double speed or variable speed machines.

**FLOOR SELECTOR:** A mechanism forming a part of the control equipment, in certain automatic lifts, designed to operate controls which cause the lift car to stop at the required landings.

**FLOOR STOPPING SWITCH:** A switch or combination of switches arranged to bring the car to rest automatically at or near any pre-selected landing.

**GEARLESS MACHINE:** A lift machine in which the motive power is transmitted to the driving sheave from the motor without intermediate reduction gearing and has the brake drum mounted directly on the motor shaft.

**GOODS LIFT:** A lift designed primarily for the transport of goods, but which may carry a lift attendant or other persons necessary for the loading or unloading of goods.

**GUIDE RAILS:** The members used to guide the movement of a lift car counterweight in a vertical direction.

**GUIDE RAILS FIXING:** The complete assy, comprising the guide rails bracket and its fastening.

**GUIDE RAILS SHOE:** An attachment to the car frame or counterweight for the purpose of guiding the lift car or counter weight frame.

**GEARED MACHINE:** A machine in which the power is transmitted to the sheave through worm or worm and spur reduction gearing.

**HOISTING BEAM:** A beam, mounted immediately below the machine room ceiling, to which lifting tackle can be fixed for raising or lowering parts of the lift machine.

**HOSPITAL LIFT:** A lift normally installed in a hospital/dispensary/clinic and designed to accommodate one number bed/stretcher along its depth, with sufficient space around to carry a minimum of three attendants in addition to the lift operator.

**LANDING CALL PUSH:** A push bottom fitted at a lift landing, either for calling the lift car, or for actuating the call indicator.

**LANDING DOOR:** The hinged or sliding portion of a lift well enclosure, controlling access to a lift car at a lift landing.

**LANDING ZONE:** A space extending from a horizontal plane 400mm below a landing to a plane 400mm above the landing.

**LEVELLING DEVICES**

**LEVELLING DEVICE LIFT CAR:** Any mechanism which either automatically or under the control of the operator, moves the car within the leveling zone towards the landing only, and automatically stops it at the landing.

**LEVELLING DEVICE, ONE WAY AUTOMATIC:** A device which corrects the car level only in case of under run of the car but will not maintain the level during loading and unloading.

**LEVELLING DEVICE, TWO WAY AUTOMATIC MAINTAINING:** A device which corrects the car level on both under run and over run but will not maintain the level during loading and unloading.

**LEVELLING ZONE:** The limited distance above or below a lift landing within which the leveling
device may cause movement of the car towards the landing.

**LIFT:** An appliance designed to transport persons or materials between two or more levels in a vertical or substantially vertical direction by means of a guided car or platform. The word 'elevator' is also synonymously used for 'lift'.

**LIFT CAR:** The load carrying unit with its floor or platform, car frame and enclosing bodywork.

**LIFT LANDING:** That portion of a building or structure used for discharge of passengers or goods or both into or from a lift car.

**LIFT MACHINE:** The part of the lift equipment comprising the motor and the control gear therewith, reduction gear (if any), brake(s) and winding drum or sheave, by which the lift car is raised or lowered.

**LIFT PIT:** The space in the lift well below the level of the lowest lift landing served.

**LIFT WELL:** The unobstructed space within an enclosure provided for the vertical movement of the lift car(s) and any counterweight(s), including the lift pit and the space for top clearance.

**LIFT WELL ENCLOSURE:** Any structure which separates the lift well from its surroundings.

**OPERATION:** The method of actuating the control of lift machine.

**AUTOMATIC OPERATION:** A method of operation in which by a momentary pressure of a button the lift car is set in motion and caused to stop automatically at any required lift landing.

**NON-SELECTIVE COLLECTIVE AUTOMATIC OPERATION:** Automatic operation by means of one button in the car for each landing level served and one button at each landing, wherein all stops registered by the momentary actuation of landing or car buttons are made irrespective of the number of buttons actuated or of the sequence in which the buttons are actuated. With this type of operation, the car stops at all landings for which buttons have been actuated making the stops in the order in which the landings are reached after the buttons have been actuated but irrespective of its direction of travel.

**SELECTIVE COLLECTIVE AUTOMATIC OPERATION:** Automatic operation by means of one button in the car for each landing level served and by up and down buttons at the landings, wherein all stops registered by the momentary actuation of the car made as defined under non-selective automatic operation, but wherein the stops registered by the momentary actuation of the landing buttons are made in the order in which the landings are reached in each direction of travel after the buttons have been actuated. With this type of operation, all 'up' landing calls are answered when the car is travelling in the up direction and all 'down' landing calls are answered when the car is travelling in the down direction, except in the case of the uppermost or lowest most calls which are answered as soon as they are reached irrespective of the direction of travel of the car.

**SINGLE AUTOMATIC OPERATION:** Automatic operation by means of one button in the car for each landing level served and one button at each landing so arranged that if any car or landing button has been actuated, the actuation of any other car or landing operation button will have no effect on the movement of the car until the response to the first button has been completed.

**GROUP AUTOMATIC OPERATION:** Automatic operation of two or more non-attendant lifts equipped with power – operated car and landing doors. The operation of the cars is co-ordinated by a supervisory operation system including automatic dispatching means whereby selected cars at designated dispatching points automatically close their doors and proceed on their trips in a regulated manner.

Typically, it includes one button in each car for each floor served and up and down buttons at each landing (single buttons at terminal landings). The stops set up by the monetary actuation of the car buttons are made automatically in succession as a car reaches the corresponding landings irrespective of its direction of travel or the sequence in which the buttons are actuated. The stops set up by the momentary actuation of the landing buttons may be accomplished by any lift in the group, and are made automatically by the first available car that approaches the landing in the corresponding direction.
CAR SWITCH OPERATION: Method of operation by which the movement of the lift car is directly under the operation of the attendant by means of a handle.

SIGNAL OPERATION: Same as collective operation, except that the closing of the door is initiated by the attendant.

Double button (continuous pressure) operation – Operation by means of buttons or switches in the car and at the landings any of which may be used to control the movement of the car as long as the button or switch is manually pressed in the actuating position.

OPERATING DEVICE: A car switch, push button or other device employed to actuate the control.

OVERHEAD BEAMS: The members, usually of steel, which immediately support the lift equipment at the top of the lift well.

OVER SPEED GOVERNOR: An automatic device which brings the lift car and/or counter weight to rest by operating the safety gear in the event of the speed in a descending direction exceeding a predetermined limit.

PASSENGER LIFT: A lift designed for the transport of passengers.

POSITION AND/OR DIRECTION INDICATOR: A device which indicates on the lift landing or in the lift car or both, the position of the car in the lift well or the direction or both in which the lift car is travelling.

RATED LOAD (LIFT): The maximum load for which the lift car is designed and installed to carry safely at its rated speed.

RATED LOAD (ESCALATOR): The load which the escalator is designed and installed to lift at the rated speed.

RATED SPEED (LIFT): The mean of the maximum speed attained by the lift car in the upward and downward direction with rated load in the lift car.

RATED SPEED (ESCALATOR): The speed at which the escalator is designed to operate. It is the rate of travel of the steps, measured along the angle of inclination, with rated load on the steps or carriage.

RETIRING CAM: A device which prevents the landing doors from being unlocked by the lift car unless it stops at a landing.

ROPING MULTIPLE: A system of roping where, in order to obtain a multiplying factor from the machine to the car, multiple falls of rope are run around the sheave on the car or counterweight or both. It includes roping arrangement of 2 to 1.3 to 1 etc.

SAFETY GEAR: A mechanical device attached to the lift car or counterweight or both, designed to stop and to hold the car or counterweight to the guides in the event of free fall, or, if governor operated, of over-speed in the descending direction. Any anticipated impact force shall be added in the general drawing or layout drawing.

SERVICE LIFT: A passenger cum goods lift meant to carry goods along with people.

Typically in an office building this may be required food or stationery, in a residential building to carry a bureau or accommodate a stretcher and in a hotel to be used for food trolleys or baggage. There is a need in such lifts, to take care of the dimensions of the car and the door clear opening in line with the type of goods that may have to be carried based on mutual discussion between supplier and customer. Also, such lifts shall have buffer railings in the car at suitable height to prevent damage to the car panels when the goods are transported. Typically such lifts, if provided with an automatic door, may use some means to detect trolley and stretcher movement in advance to protect the doors against damage. The car floor load calculations and car area of such a lift is as in the case of a passenger lift except that these are not meant carry heavy concentrated loads.

SHEAVE: A rope wheel, the rim of which is grooved to receive the suspension ropes but to which the ropes are not rigidly attached and by means of which power is transmitted from the lift machine to the suspension ropes.

SLACK ROPE SWITCH: Switch provided to open the control circuit in case of slackening of rope(s).
SUSPENSION ROPES: The ropes by which the car and counter weight are suspended.

TERMINAL SLOW DOWN SWITCH: A switch which when actuated shall compulsorily cut off the high speed and switch on the circuitry to run the lift in leveling speed before reaching on terminal landings.

TERMINAL STOPPING SWITCH NORMAL: Switch for cutting all the energizing current in case of car travelling beyond the top bottom landing or a switch cuts off the energizing current so as to bring the car to stop at the top and bottom level.

TERMINAL STOPPING DEVICE FINAL: A device which automatically cause the power to be removed from an electric lift driving machine motor and brake, independent of the functioning of the normal terminal stopping device, the operating device or any emergency terminal stopping device, after the car has passed a terminal landing.

TOTAL HEADROOM: The vertical distance from the level of the top lift landing to the bottom of the machine room slab.

TRAVEL: The vertical distance between the bottom and top lift landing served.

31.1.3 General

31.1.3.1 The appropriate aspect of lift and escalator installation shall be discussed during the preliminary planning of the building with all the concerned parties, namely, client, architect, consulting engineer and/or lift/escalator manufacturer. This enables the lift/escalator manufacturer to furnish the architect and/or consulting engineer with the proposed layout or vice – versa.

31.1.3.2 Exchange of information

31.1.3.2.1 If the proposed installation is within the scope of Clause 31.1.6 the guidelines laid down together with Fig.1 will enable the preliminary scheme for the installation to be established. Figure 1 shows only some of the typical arrangements and variations that are possible with respect to number of lifts and the layout. Although the recommended outline for the various classes of lifts given in Clause 31.1.6 enables the general planning details to be determined by the architect, these should be finally settled at the earliest possible stage by detailed investigation with the purchaser's representative reaching agreement with the lift maker where necessary before an order is finally placed. This will enable a check to be made and information to be exchanged on such vital matters as:

a) the number, capacity, speed and disposition of the lifts necessary to give adequate lift service in the proposed building;

b) the provision of adequate access to the machine room;

c) the loads which the lift will impose on the building structure, and the holes to be left in the machine room floor and cut-outs for wall boxes for push-buttons and signals;

d) The necessity for and type of insulation to minimize the transmission of vibration and noise to other parts of the building;

e) The special requirements of local authorities and other requirements set out in the ‘planning permit’;

f) The need for the builder to maintain accuracy of building as to dimensions and in plumb;

g) The periods of time required for preparation and approval of relevant drawings for manufacturing and the installation of the lift equipment;

h) The requirements for fixing guide brackets to the building structure;

i) The time at which electric power will be required before completion to allow for testing;

j) The requirements for electrical; supply feeders, etc;

k) The requirements for scaffolding in the lift well and protection of the lift well prior to and during installation of equipment; and

l) Delivery and storage of equipment.

31.1.3.2.2 Information to be provided by Architect or Engineer

As a result of preliminary discussion (see also 31.1.6, the drawings of the building should give the following particulars and finished sizes:
a) number, type and size of lifts and position of lift well;
b) particulars of lift well enclosure;
c) size, position, number and type of landing doors;
d) number of floors served by the lift;
e) height between floor levels;
f) number of entrances;
g) total headroom;
h) provision of ventilation and, if possible, natural lighting of machine room;
i) height of machine room;
j) depth of lift pit;
k) position of lift machine, above or below lift well;
l) size and position of any trimmer joists or stanchions adjacent to the lift well at each floor;
m) size and position or supporting steel work at roof levels;
n) size and position of any footings or grillage foundations, if these are adjacent to the lift pit; and
o) in the case of passenger lifts, whether the lift cage is required to carry household luggage, such as refrigerator, etc.

31.1.3.2.2.1 The lift lobby should be designed appropriately since this has bearing on the traffic handling especially when more number of lifts are involved. In a dual line arrangement (lifts opposite to each other) the lobby can be between 1.5 times to 2.5 times the depth of one car. Typically, the more the number of lifts, the bigger the multiple to be used. As an example a quadruplex may use 1.5 to 2 times where as an octoplex will need 2 to 2.5 times. For in-line (single line) arrangements, the lobby can be typically half of the above recommendations.

It is preferable that the lift lobby is not used as a thoroughfare but in such cases the lift corridor shall take into account space for people who are moving.

31.1.3.2.2 The architect/engineer should advise the lift manufacturer, if the Authority having jurisdiction has any special requirements regarding lifts in buildings in the administrative area concerned.

31.1.3.2.3 The information contained under 31.1.3.2.1 and 31.1.3.2.2 is applicable for the installation of lifts only and in the case of escalator installations, the drawings shall provide the appropriate information.

31.1.3.2.4 The architect/engineer should inform the lift/escalator manufacturer of the dates when the erection of the lift/escalator may be commenced and is to be completed so that sufficient time is allowed for the manufacture and erection of the lift/escalator.

31.1.3.2.5 When submitting application for a building permit to the local Authority, the building plans shall include the details of lifts (number of lifts duly numbered, location, type, type of doors, passenger capacity and speed).

31.1.3.2.3 Working drawings to be prepared by the lift/escalator manufacturer

The lift/escalator manufacturer requires sufficient information for the preparation of working drawings and is usually obtained from architect’s drawings supplemented by any information obtained from the site and by collaboration with the other contractors.

31.1.3.2.3.1 Working drawings showing the layout of lift/escalator duly numbered, details of builders work, for example, holes in walls for guide fixing, holes in machine room floor for ropes and conduits, recesses for landing sills, supports for lift/escalator machine and loads imposed on the building should be submitted by the lift/escalator manufacturer to the architect/engineer for written approval.

31.1.3.3 Electrical requirement

For information of the electrical engineer, the lift/escalator manufacturer should advise the architect/engineer of the electrical requirements. This information should be available early in the planning stage so that the electrical supply requirements of the lift(s)/escalator(s) may be included in the electrical provisions of the building and that suitable cables and switchgear may be provided.

31.1.3.4 The requirements given under Clause 31.1.4 to 31.1.12 deal with installation of lifts and Clause 31.1.13 deals with the installation of escalators.
31.1.4 Essential requirements

31.1.4.1 It is the responsibility of the owner of the premises where the lift will be installed, to obtain the necessary permission including pattern approval from the Authority having jurisdiction before and after the erection of lifts and for subsequent operation of lift(s).

31.1.4.2 Conformity with GS 1009 Ghana Electrical Wiring Code

All electrical work in connection with installation of electric lifts shall be carried out in accordance with the provisions GS 1009.

31.1.4.3 Conformity with Ghana Standards

31.1.4.3.1 All materials, fittings, appliances etc. used in electrical installation shall conform to Ghana Standard specifications wherever these exist. In case of materials for which Ghana Standard specifications do not exist, the materials shall be approved by the competent authority. For detailed specification for lifts, reference shall be made to accepted standards.

31.1.4.4 Conformity with Fire Regulations

31.1.4.4.1 The installation shall be carried out in conformity with Part 3 Use and occupancy classification and local fire regulations and rules thereunder wherever they are in force.

31.1.4.5 Factor of safety

The minimum factor of safety for any part of the lift shall not be less than five. Higher factor of safety for various parts shall be applicable in accordance with accepted standards.

31.1.4.6 Additional requirements for passenger and good lifts

31.1.4.6.1 Bottom and top car clearances

31.1.4.6.1.1 Bottom car clearance

When the car rests on its fully compressed buffer there shall be a vertical clearance of not less than 600 mm between the pit floor and the buffer striker plate or the lowest structural or mechanical part equipment or device installed. The clearance shall be available beneath the whole area of the platform except for:

a) guide shoes or rollers, safety jaw blocks, platform aprons, guards of other equipment located within 300mm measured horizontally from the sides of the car platform; and

b) compensating sheaves.

Provided that in all cases, including small cars, a minimum clearance of 600mm is available over a horizontal area of 800mm by 500mm.

Provided also that in all the cases when the car rests on its fully compressed buffers, there shall be a vertical clearance of not less than 50mm between any part of the car and any obstruction of device mounted in the pit.

31.1.4.6.1.2 Top car clearance

The vertical clearance between the car cross-head and the nearest overhead obstruction within 500mm measured horizontally to the nearest part of the cross head when the car platform is level with the top landing, shall be not less than the sum of the following:

a) the bottom counterweight runby;

b) the stroke of the counterweight buffer used;

c) one-half of the gravity stopping distance based on:

1) 115 percent of the rated speed where oil buffers are used and no provision is made to prevent the jump of the car at counterweight buffer engagement; and

2) governor tripping speed where spring buffers are used.

Note: The gravity stopping distance based on the gravity retardation from any initial velocity may be calculated according to the following formula:

\[ S = \frac{1}{2} V^2 \]

Where,

\[ S = \text{Free fall in mm (gravity stopping distance), and} \]
V = Initial velocity in m/s

d) 600 mm.

Where there is a projection below the ceiling of the well and the projection is more than 500 mm, measured horizontally from the center line of the cross-head but over the roof of the car, a minimum vertical clearance not less than that calculated above shall also be available between the roof of the car and the projection.

Provided that the vertical clearance between any equipment mounted on top of the car and the nearest overhead obstruction shall be not less than the sum of the three items (a), (b) and (c) as calculated above, plus 150mm.

31.1.4.6.2 Bottom runby for cars and counterweights

31.1.4.6.2.1 The bottom runby of cars and counterweights shall be not less than the following:

a) 150mm where oil buffers are used;

b) where spring-buffers are used;

1) 150mm for controls as in Clause 9.5.2.12.4 to 9.5.2.12.8.

2) not less than the following for controls as in Clause 9.5.2.12.2 to 9.5.2.12.3.

<table>
<thead>
<tr>
<th>Rated Speed (m/s)</th>
<th>Runby (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 0.125</td>
<td>75</td>
</tr>
<tr>
<td>0.125 to 0.25</td>
<td>150</td>
</tr>
<tr>
<td>0.25 to 0.50</td>
<td>225</td>
</tr>
<tr>
<td>0.50 to 1.0</td>
<td>300</td>
</tr>
</tbody>
</table>

31.1.4.6.3 Maximum bottom runby

In no case shall the maximum bottom runby exceed the following:

a) 600 mm for cars; and

b) 900 mm for counterweights.

31.1.4.6.4 Top counterweight clearances

The top counterweight clearances shall be not less than the sum of the following four items:

a) the bottom car runby;

b) the stroke of the car buffer used;

c) 150 mm; and

d) one-half the gravity stopping distance based on:

1) one hundred and fifteen percent of the rated speed where oil buffers are used and no provision is made to prevent jump of the counterweight at car buffer engagement; and

2) governor tripping speed where spring buffers are used.

31.1.4.7 Additional requirements for service lifts

31.1.4.7.1 Top and bottom clearances for car and counterweights

31.1.4.7.1.1 Top car clearance

The top car clearance shall be sufficient to avoid any protruding part fixed on the top of the car coming in direct contact with the ceiling or diverting sheave.

The clearance shall be calculated taking into account the following and shall not be less than the sum of the following four items:

a) the bottom counterweight runby;

b) the stroke of the counterweight buffer used;

c) the dimensions of the portion of the diverting sheave hanging underneath the ceiling in the lift well; and

d) 150mm for compensating for gravity stopping distance and future repairs to the rope connections at counterweight and at the car or at the suspension points.

31.1.4.7.1.2 Bottom car clearance

The bottom car clearance shall be maintained in such a way that the counterweight shall not come in contact with the ceiling or any part hanging underneath the ceiling, when the car completely rests on fully compressed buffers,
provided the buffers are of the spring type, mounted on solid concrete or steel bed.

In the case of wooden buffers, the bottom car clearance shall be maintained in such a way that the total downward travel of the car from the service level of the immediate floor near the pit, shall not be more than the top counterweight clearance, when the wooden buffers are completely crushed.

31.1.4.7.1.3 Top counterweight clearance
The top clearance for the counterweight can be calculated taking into account the following and shall not be less than the sum of the following three items:

a) car runby;
b) compression of the buffer spring or height of the wooden block used as buffer; and
c) 150 mm to compensate for gravity stopping distance for the counterweight and any future repairs to rope connections at the counterweight at the car ends or at the suspension points.

31.1.4.7.1.4 Runby for cars and counterweights
The bottom runby for cars and counterweights shall not be less than 150 mm.

31.1.4.7.1.5 Maximum bottom runby
In no case shall the maximum bottom runby exceed 300 mm.

31.1.4.8 In order to maintain a safe work environment, and to avoid potential hazards, the following shall be provided:

a) caution sign shall be installed in the areas listed below where potential hazard exists;
   1) trip hazard in machine room; and
   2) caution notice against unauthorized use of rescue devices (for example, brake release device).

b) use the hard hats for entry in pit and car top during construction period;
c) warning sign shall be provided on the controller so as to eliminate, the possibility of contact with any exposed or concealed power circuit;
d) car top barricade system shall be provided as primary protection against fall, on car top;
e) whenever work is carried out on the lift and lift is not required to be moved on power, notice shall be put on the electrical main switch, indicating requirement of de-energized condition;
f) during lift installation/maintenance, protection against fall shall be provided with suitable barricades for all open landing entrances.

31.1.4.9 Planning for dimensions
31.1.4.9.1 General
The dimensions of the lift well have been chosen to accommodate the doors inside the well which is the normal practice. In special cases, the door may be accommodated in a recess in the front wall, for which prior consultation shall be made with the lift manufacturer.

31.1.4.9.2 Plan dimensions
31.1.4.9.2.1 All plan dimensions of the lift well are the minimum clear plumb sizes. The architect/engineer, in conjunction with the builder, shall ensure that adequate tolerances are included in the building design so that the specified minimum clear plumb dimensions are obtained in the finished work.

Note – The words ‘clear plumb dimensions’ should be noted particularly in case of high rise buildings.

31.1.4.9.2.2 Rough opening in concrete or brick walls to accommodate landing doors depend on the design of the architrave. It is advisable to provide sufficient allowances in rough opening width to allow for alignment errors of opening at various landings.

31.1.4.9.2.3 When more than one lift is located in a common well, a minimum allowance of 100 mm for separator beams shall be made in the widths shown in Tables 1 to 4.
31.1.4.9.2.4 Where the governor operated counterweight safety is required under conditions stipulated in good practice, the tabulated values should be revised in consultation with the lift manufacturer.

31.1.4.9.2.5 For outline dimensions of lifts having more than one car entrance, lift manufacturers should be consulted.

31.1.4.9.3 Outline dimensions

31.1.4.9.3.1 The outline dimensions of machine-room, pit depth, total headroom, overhead distance and sill for four classes of lifts to which the standard applies are specified in Tables 1 to 4 as indicated below:

<p>| Table 1: Recommended dimensions of passenger lifts and service lifts (Clauses 31.1.4.9.2.3 and 31.1.4.9.3.1) All dimensions in millimeters Table 1 – Concluded |
| Load | Car Side | Lift Well |</p>
<table>
<thead>
<tr>
<th>Persons</th>
<th>kg</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>272</td>
<td>1100</td>
<td>700</td>
<td>1900</td>
<td>1300</td>
</tr>
<tr>
<td>6</td>
<td>408</td>
<td>1100</td>
<td>1000</td>
<td>1900</td>
<td>1700</td>
</tr>
<tr>
<td>8</td>
<td>544</td>
<td>1300</td>
<td>1100</td>
<td>1900</td>
<td>1900</td>
</tr>
<tr>
<td>10</td>
<td>680</td>
<td>1300</td>
<td>1350</td>
<td>1900</td>
<td>2100</td>
</tr>
<tr>
<td>13</td>
<td>884</td>
<td>2000</td>
<td>1100</td>
<td>2500</td>
<td>1900</td>
</tr>
<tr>
<td>16</td>
<td>1088</td>
<td>2000</td>
<td>1300</td>
<td>2500</td>
<td>2100</td>
</tr>
<tr>
<td>20</td>
<td>1360</td>
<td>2000</td>
<td>1500</td>
<td>2500</td>
<td>2400</td>
</tr>
</tbody>
</table>

<p>| Table 1A: Recommended dimensions of pit, overhead and machine-room for passenger lifts and service lifts (Clauses 31.1.4.9.2.3 and 31.1.4.9.3.1) All dimensions in millimeters |</p>
<table>
<thead>
<tr>
<th>Speed in m/s</th>
<th>Up to 0.70</th>
<th>&gt;0.70 ≤ 1.00</th>
<th>&gt;1.00 ≤ 1.50</th>
<th>&gt;1.50 ≤ 1.75</th>
<th>&gt;1.75 ≤ 2.00</th>
<th>&gt;2.00 ≤ 2.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit depth</td>
<td>1350</td>
<td>1500</td>
<td>1600</td>
<td>2150</td>
<td>2200</td>
<td>2500</td>
</tr>
<tr>
<td>Overhead</td>
<td>4200</td>
<td>4250</td>
<td>4800</td>
<td>4800</td>
<td>5200</td>
<td>5400</td>
</tr>
<tr>
<td>Machine-room Depth</td>
<td>D + 2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D + 2500</td>
</tr>
</tbody>
</table>
### Machine-room

<table>
<thead>
<tr>
<th>Width</th>
<th>C + 2000</th>
<th>C + 1200</th>
<th>C + 1500</th>
</tr>
</thead>
</table>

### Notes

1. The total overhead dimension has been calculated on the basis of car height of 2.3m.
2. In case of manually operated doors, clear entrance will be reduced by the amount of projection of handle on the landing door.
3. All dimensions given above for lifts having centre opening power operated doors with counterweight at rear, are recommended dimensions primarily for architects and building planners. Any variations mutually agreed between the manufacturer and the purchaser is permitted. However, variation in:
   a) Car inside dimensions shall be within the maximum area limits specified in accordance with accepted standards [8-6(4)].
   b) Entrance width on higher side is permitted.
   c) Entrance width on lower side is permitted up to 100 mm subject to minimum of 700mm.

4. Dimensions of pit depth and overhead may differ in practice as per individual manufacturer’s design depending upon load, speed and drive. Recommended dimensions for pit depth, overhead and machine-room for different lift speeds are given in Table 1A. However, the pit depth and overhead shall be such as to conform to the requirements of bottom clearance and top clearance in accordance with the accepted standards.

### Table 2: Recommended dimensions of goods lifts for speeds up to 0.5 m/s

(Clauses 31.1.4.9.2.3 and 31.1.4.9.3.1)

<table>
<thead>
<tr>
<th>Load Kg</th>
<th>Car Inside</th>
<th>Lift Well</th>
<th>Entrance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>500</td>
<td>1100</td>
<td>1200</td>
<td>1900</td>
</tr>
<tr>
<td>1000</td>
<td>1400</td>
<td>1800</td>
<td>2300</td>
</tr>
<tr>
<td>1500</td>
<td>1700</td>
<td>2000</td>
<td>2600</td>
</tr>
<tr>
<td>2000</td>
<td>1700</td>
<td>2500</td>
<td>2600</td>
</tr>
<tr>
<td>2500</td>
<td>2000</td>
<td>2500</td>
<td>2900</td>
</tr>
<tr>
<td>3000</td>
<td>2000</td>
<td>3000</td>
<td>2900</td>
</tr>
<tr>
<td>4000</td>
<td>2500</td>
<td>3000</td>
<td>3400</td>
</tr>
<tr>
<td>5000</td>
<td>2500</td>
<td>3600</td>
<td>3400</td>
</tr>
</tbody>
</table>

### Notes

1. The width of machine room shall be equal to be lift well width ‘C’ subject to minimum of 2500mm.
2. The total headroom has been calculated on the basis of car height of 2.2m.
3. Clear entrance width ‘E’ is based on vertical lifting car-door and vertical bi-parting landing doors. For collapsible mid-bar doors the clear entrance width will be reduced by 200mm (maximum 1800 mm).
4. All dimensions given above are recommended dimensions primarily for architects and building planners. Any variations mutually agreed between the manufacturer and the purchaser are permitted. However, variation in car inside dimensions shall be within the maximum area limits in accordance with accepted standards.
5. Dimensions of pit depth and overhead may differ in practice as per individual manufacturer’s design depending upon load, speed and drive. However, the pit depth and overhead shall be such as to conform to the requirements of bottom clearance and top clearance in accordance with the accepted standards.

### Table 3: Recommended dimensions of hospital lifts (for speeds up to 0.5 m/s)

(Clauses 31.1.4.9.2.3 and 31.1.4.9.3.1)

All dimensions in millimeters

<table>
<thead>
<tr>
<th>Load Kg</th>
<th>Car Inside</th>
<th>Lift Well</th>
<th>Entrance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>500</td>
<td>1100</td>
<td>1200</td>
<td>1900</td>
</tr>
<tr>
<td>1000</td>
<td>1400</td>
<td>1800</td>
<td>2300</td>
</tr>
<tr>
<td>1500</td>
<td>1700</td>
<td>2000</td>
<td>2600</td>
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<tr>
<td>2000</td>
<td>1700</td>
<td>2500</td>
<td>2600</td>
</tr>
<tr>
<td>2500</td>
<td>2000</td>
<td>2500</td>
<td>2900</td>
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<tr>
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<tr>
<td>4000</td>
<td>2500</td>
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<td>3400</td>
</tr>
<tr>
<td>5000</td>
<td>2500</td>
<td>3600</td>
<td>3400</td>
</tr>
</tbody>
</table>

### Notes

1. The width of machine room shall be equal to be lift well width ‘C’ subject to minimum of 2500mm.
2. The total headroom has been calculated on the basis of car height of 2.2m.
3. Clear entrance width ‘E’ is based on vertical lifting car-door and vertical bi-parting landing doors. For collapsible mid-bar doors the clear entrance width will be reduced by 200mm (maximum 1800 mm).
4. All dimensions given above are recommended dimensions primarily for architects and building planners. Any variations mutually agreed between the manufacturer and the purchaser are permitted. However, variation in car inside dimensions shall be within the maximum area limits in accordance with accepted standards.
5. Dimensions of pit depth and overhead may differ in practice as per individual manufacturer’s design depending upon load, speed and drive. However, the pit depth and overhead shall be such as to conform to the requirements of bottom clearance and top clearance in accordance with the accepted standards.
Table 4: Recommended dimensions of dumb waiter (for speeds up to 0.5 m/s)
(Clauses 31.1.4.9.2.3 and 31.1.4.9.3.1)
All dimensions in millimeters

<table>
<thead>
<tr>
<th>Load Kg</th>
<th>Car Inside</th>
<th>Lift Well</th>
<th>Entrance E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>100</td>
<td>700</td>
<td>700</td>
<td>800</td>
</tr>
<tr>
<td>150</td>
<td>800</td>
<td>800</td>
<td>900</td>
</tr>
<tr>
<td>200</td>
<td>900</td>
<td>900</td>
<td>1000</td>
</tr>
<tr>
<td>250</td>
<td>1000</td>
<td>1000</td>
<td>1200</td>
</tr>
</tbody>
</table>

**Notes**

1. The total headroom has been calculated on the basis of car height of 2.2m
2. In case of manually operated doors, clear entrance will be reduced by the amount of projection of handle on the landing door.
3. Although 15 persons capacity lift is not standard one, this is included to cover lifts of smaller capacity which can be used in small hospitals.
4. All dimensions given above are recommended dimensions primarily for architects and building planners. Any variations mutually agreed between the manufacturer and the purchaser are permitted. However, variation in car inside dimensions shall be within the maximum area limits in accordance with accepted standards.
5. Dimensions of pit depth and overhead may differ in practice as per individual manufacturer’s design depending upon load, speed and drive. However, the pit depth and overhead shall be such as to conform to the requirements of bottom clearance and top clearance in accordance with the accepted standards.

**Table 4:** Recommended dimensions of dumb waiter (for speeds up to 0.5 m/s)
(Clauses 31.1.4.9.2.3 and 31.1.4.9.3.1)
All dimensions in millimeters

<table>
<thead>
<tr>
<th>Load Kg</th>
<th>Car Inside</th>
<th>Lift Well</th>
<th>Entrance E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
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</tr>
<tr>
<td>200</td>
<td>900</td>
<td>900</td>
<td>1000</td>
</tr>
<tr>
<td>250</td>
<td>1000</td>
<td>1000</td>
<td>1200</td>
</tr>
</tbody>
</table>

**Note** - Entrance width “E” is based on assumption of vertical bi-parting doors (no car door is normally provided).

31.1.4.9.3.2 Travel
The tables have been established for a maximum travel of 30 m. For travels above 30 m, the lift manufacturer should be consulted.

31.1.4.9.3.3 Pit
The pit depth of the lifts will normally accommodate compensating chains. If compensating ropes are required, pit depth shall be increased for all loads and speeds and the lift manufacturer should be consulted.

31.1.4.9.3.4 Minimum floor to floor height
Minimum floor to floor height for landings on same side for horizontally sliding door is \( f + 750 \) mm and for vertically bi-parting doors is \( 1.5f + 250 \) mm, where \( f \) is the clear entrance height in mm.
31.1.4.10 Lift wells and lift well enclosures

31.1.4.10.1 Lift wells

31.1.4.10.1.1 No equipment except that forming a part of the lift or necessary for its operation and maintenance shall be installed in the lift well. For this purpose, the main supply lines shall be deemed to be a part of the lift and the underground cable, if laid along the lift well shaft, shall be properly clamped to the wall.

31.1.4.10.1.2 Sufficient space shall be provided between the guides for the cars and the side walls of the lift well enclosure to allow safe and easy access to the parts of the safety gears for their maintenance and repairs; safety gears provided shall be in accordance with good practices.

31.1.4.10.1.3 Lift wells, together with the whole of the contained equipment and apparatus, shall be rendered fire resistant to the greatest possible extent (see also Clause 31.1.4.4.1).

31.1.4.10.1.4 Every counterweight shall travel in juxtaposition to its car in the same lift well.

31.1.4.10.1.5 It is undesirable that any room, passage or thoroughfare be permitted under any lift well. If unavoidable, spaces for other uses may be permitted under the lift well, with the prior approval of the Lift Inspectorate Authority and the following provisions shall be made:

   a) spring or oil buffers shall be provided for the lift car and counterweight;

   b) the pit shall be sufficiently strong to withstand successfully, the impact of the lift car with rated load or the impact of the counterweight when either is descending at rated speed or at governor tripping speed;

   c) the car and the counterweight shall be provided with a governor-operated safety gear; and

   d) the forces required on the structure in the event of car buffering directly without safety gear application to be indicated in the general arrangement drawing.

31.1.4.10.2 Lift well enclosures

31.1.4.10.2.1 Lift well enclosures shall be provided and shall extend on all sides from floor-to-floor or stair-to-stair, and shall have requisite strength and in proper plumb.

31.1.4.10.2.2 The inner sides of the lift well enclosures facing any car entrance shall, as far as practicable, form a smooth, continuous flush surface devoid of projections or recesses.

Note – This requirement may be met in existing lift wells by filling any recesses or spaces between projections or alternatively by covering them with suitable sheet material. If it is not possible to render flush any objection or tops of recesses, they should be bevelled on the underside to an angle of 60°, from the horizontal by means of metal plates, cement rendering or other fire-resisting materials. Where a car-levelling device is operative with car door opening, such interior surfaces shall always form a smooth flush surface below each landing level for a depth to at least the depth of the car-levelling zone plus the distance through which the lift car may travel of its own momentum when the power is cut-off.

31.1.4.10.2.3 Where an open lift well would increase the fire risk in a building, the lift well enclosure shall be of fire-resisting construction see Part 3 Use and Occupancy classification

31.1.4.10.2.4 Where wire grill or similar constructions is used, the mesh or opening shall be such that the opening between the bars shall reject the ball of 40 mm in diameter and the lift well enclosure shall be of sufficient strength to resist accidental impact by users of the staircase on adjoining floors or by materials or trucks being moved in the vicinity.

31.1.4.10.2.5 Where the clearance between the inside of an open-type lift well enclosure and any moving or movable part of the lift equipment of apparatus is less than 55 mm, the openings in the enclosure shall be further protected by netting of square mesh of aperture not greater than one centimeter and of wire not smaller than one mm. (The provisions of this clause need not be adhered to for lift wells in factory premises, coming under the purview of Factories Act. In such cases provisions of Clause 31.1.4.10.2.4 are sufficient).

31.1.4.10.2.6 There shall be no opening in the lift well enclosure permitting access to the lift car by passing under the counterweight.
31.1.4.10.2.7 In case of a completely enclosed lift well, a notice with the word ‘Lift’ may be placed outside of each landing door.

31.1.4.10.2.8 Indicator
Where lifts are installed in totally enclosed wells, position indicators are recommended to be provided at each floor, however, where position indicators are not provided, at least direction indicators or ‘In Use’ indicators shall be provided at each landing.

9.5.4.10.2.9 Landing doors
Every lift well shall, on each side from which there is access to a car, be fitted with a door. Such a door shall be fitted with efficient electro mechanical locking so as to ensure that it cannot be opened except when the lift car is at landing and that the lift car cannot be moved away from the landing until the door is closed and locked. If the door is mechanically locked, means should be provided for opening the same by means of special key during emergency or inspection.

31.1.4.10.2.10 Automatic devices for cutting off power
An efficient automatic device shall be provided and maintained in each lift whereby all powershall be cut off from the motor before the car or counterweight lands on buffer.

31.1.4.10.3 Lift pits
31.1.4.10.3.1 A lift pit shall be provided at the bottom of every lift.

31.1.4.10.3.2 Pits shall be of sound construction and maintained in a dry and clean condition. Where necessary, provision shall be made for permanent drainage and where the pit depth exceeds 1.5m, suitable descending arrangement shall be provided to reach the lift pit. And, a suitable fixed ladder or other descending facility in the form of permanent brackets grouted in the wall extending to a height of 0.75 m above the lowest floor level shall be provided. A light point with a switch shall also be provided for facility of maintenance and repair work.

31.1.4.11 Machine rooms and overhead structures
31.1.4.11.1 The lift machine, controller and all other apparatus and equipment of a lift installation, excepting such apparatus and equipment as function in the lift well or other positions, shall be placed in the machine room which shall be adequately lighted and rendered fire-proof and weather-proof.

31.1.4.11.2 The motor generator controlling the speed of multi-voltage or variable voltage machines, secondary sheaves, pulleys, governors and floor selecting equipment may be placed in a place other than the machine room, but such position shall be adequately lighted, ventilated and rendered fire-proof and weather proof.

31.1.4.11.3 The machine room shall have sufficient floor area as well as permit free access to all parts of the machines and equipment located therein for purposes of inspection, maintenance or repair.

31.1.4.11.4 The room shall be kept closed, except to those who are concerned with the operation and maintenance of the equipment. When the electrical voltage exceeds 220/230V ac, a danger notice plate shall be displayed permanently on the outside of the door and on or near the machinery. Where standby generator is provided, it is necessary to connect fireman lift to the standby generator. Depending upon the capacity of the standby generator one or more other lifts may also be connected to the supply.

Rescue instruction with required tools and tackles if any, shall be made available in the machine room.

All lifts which do not have any automatic transfer facility to an alternate supply, such as generators, shall be equipped with Battery Operated Automatic Rescue Device to bring the lift to the nearest floor and open the door in the event of power failure.

31.1.4.11.5 The machine room shall be equipped with an insulated portable hand lamp provided with flexible cord for examining the machinery.
31.1.4.11.6 If any machine room floor or platform does not extend to the enclosing walls, the open sides shall be provided with hand rails or otherwise suitably guarded.

31.1.4.11.7 The machine room shall not be used as a store room or for any purpose other than housing the lift machinery and its associated apparatus and equipment.

31.1.4.11.8 Machine room floor shall be provided with a trap door, if necessary. The size of the trap door shall be as per manufacturer’s recommendation.

31.1.4.11.9 The height of the machine room shall be sufficient to allow any portion of equipment to be accessible and removable for repair and replacement and shall not be less than 2m clear from the floor or the platform of machine whichever is higher.

31.1.4.11.10 It will be noted that generally lifts have machine rooms immediately over the lift well, and this should be arranged whenever possible without restricting the overhead distance required for normal safety precautions. In case where machine room provision on top is a limitation, either machine room less lift or basement drive or side drive lift can be considered.

31.1.4.11.11 For detail information regarding nomenclature of floors and storeys, reference may be made to good practice.

31.1.4.12 Essential features required

31.1.4.12.1 Power operated car doors on automatically operated lifts shall be so designed that their closing and opening is not likely to injure a person. The power operated car door shall be provided with a sensitive device which shall automatically initiate reopening of the door in the event of a passenger being struck or is about to be struck by the door, while crossing the entrance during closing movement. The effect of the device may be neutralized:

- a) during the last 58 mm of travel of door panel in case of side opening doors;
- b) when panels are within 58 mm of each other in case of centre opening doors.

The force needed to prevent the door from closing shall not exceed 150N and this measurement shall not be made in the first third of the travel of the door.

In order to achieve this it is desirable that all power operated doors have a full length (covering at least 80 percent of the car door height from the bottom) infra red light curtain safety to retract the door in the event of coming across any obstacle during closing of the door.

31.1.4.12.2 Single speed and two speed drives which are poor in leveling accuracy and energy consumption shall not be used for new lifts in view of availability of latest technology energy efficient Variable Voltage Variable Frequency drive systems with improved leveling accuracy.

31.1.4.12.3 For passenger lifts with car call button control in car and with capacities of 16 passengers and above, it is recommended to have an additional car operating panel with call buttons on the opposite side to the main panel for ease of access to buttons.
31.1.4.12.4 Passenger lifts shall be provided with power operated doors which are imperforate.

31.1.5 Dimensional tolerances

31.1.5.1 Lift well dimensions

Plan dimensions of lift wells given by the lift manufacturer represent the minimum clear plumb sizes. The purchaser's representative, in conjunction with the manufacturer, should ensure that adequate tolerances are included in the building design so that the specified minimum plumb dimensions are obtained in the finished work.

Dimensions in excess of these minimum plumb dimensions for lift well and openings (but not less) can be accommodated by the lift manufacturer up to certain maximum values beyond which changes in design may be necessary involving additional expense or work by the manufacture. The purchaser's representative should take these factors into account when specifying the lift well structural dimensions on the basis of the constructional tolerance appropriate to the building technique.

31.1.5.2 Landing door openings

It is very important that finished landing openings should be accurate to design size and plumb one above the other for the full travel of the lift. In constructing the structural openings in concrete walls of lift wells, it is not possible to achieve a degree of accuracy vertically which will allow doors and frames to be inserted in the opening without some form of masking or packing to overcome inaccuracies. Provisions should therefore be made in design by increasing the nominal height from design finished floor level and width of openings to each jamb and head.

In addition, the alignment of the outer face of the front wall of the lift well is of importance when architraves of fixed dimensions are called for, and in this case the alignment of the outer face from floor to floor should not vary to a greater extent than can be accommodated by the subsequent front wall finish, the architrave being set accurately plumb.

To facilitate accurate alignment of landing sills it is common practice to provide at each landing, an independent threshold, the position of which can be adjusted.

31.1.5.3 Structural limits for lift wells at any level

If the net plumb well (dimensions A and B of Fig. 2) and the nominal structural entrance openings (dimensions C and D of Fig. 2) are defined by plumb lines, the actual wall should not encroach on these dimensions.

Dimension K (inside face of wall of Fig.2) should fall within the following limits:

- For wells up to 30 m: 0.25mm
- For wells up to 60 m: 0.35mm
- For wells up to 90 m: 0.50mm

When architraves are to be supplied by the lift manufacturer, dimension L (side of structural opening of Fig. 2) should fall within the limits of 0 and 25 mm and dimension M (outer face of the front wall of Fig. 2) should not vary to a greater extent than can be accommodated by the subsequent front wall finish, the architrave being set accurately plumb.

When the entrance linings are supplied by the manufacture, corresponding provision should be made for the finished openings to be accurately plumb one above the other for the full travel of the lift end to design size.

31.1.6 Preliminary design

31.1.6.1 Number of lifts and capacity

31.1.6.1.1 Two basic considerations, namely, the quantity of service required and the quality of service desired, determine the type of lifts to be provided in a particular building. Quantity of service gives the passenger handling capacity of the lifts during the peak periods and the quality of service is measured in terms of waiting time of passengers at various floors. Both these basic factors require proper study into the character of the building, extend and duration of peak periods, frequency of service required, type and method of control, type of landing doors etc. In busy cities, patience coefficient being low, satisfaction cannot be obtained if lifts with adequate capacities and speeds are not
provided. In view of many variables, no simple formula is possible for determining the most suitable lifts.

**Note:** It is recommended to do a Traffic Analysis Study to ensure optimum provision of lifts for the building in consultation with lift manufacturers. In view of the dynamic situation it is recommended that a computerized software is used for the Traffic Analysis Study.

31.1.6.1.2 The number of passenger lifts and their capacities, that is load and speed, required for a given building depend on the characteristics of the building. The most important of these are:

a) number of floors to be served by the lift;  
b) floor to floor distance;  
c) population of each floor to be served; and  
d) maximum peak demand; this demand may be unidirectional, as in up and down peak periods, or a two-way traffic movement.

It should be appreciated that all calculations on the traffic handling capabilities of lifts are dependent on a number of factors which vary according to the design of lift and the assumptions made on passenger actions. It follows, therefore, that the result of such calculations can only be put to limited use of a comparative nature. For instance, they can with advantage be used to compare the capabilities of lifts in a bank with different loads and speeds provided the same set of factors are used for all cases. On the other hand, they cannot be used to compare the capabilities of different makes of lift used for a given bank of lifts.

Different authorities and manufacturers differ widely in their methods of calculation, due to the variations in lift performance, especially with regard to rates of acceleration and deceleration and door operation times which form the components of performance time. Therefore, the calculations made by different organizations will not necessarily agree.

31.1.6.2 Preliminary lift planning

31.1.6.2.1 General

Methods of calculating the traffic handling capabilities of lifts were first devised for office buildings. In due course detailed modifications were devised to suit other applications without altering the basic principles. The application to office buildings is still the most frequently used. Therefore, the following method may be used as general guidance on preliminary lift planning for offices, bearing in mind the differences set out in Clause 31.1.6.1.2.

A lift installation for an office building is normally designed to populate the building at a given rate and the three main factors to be considered are:

a) population or the number of people who require lift service;  
b) handling capacity of the maximum flow rate required by these people;  
c) interval or the quality of service required.

31.1.6.2.2 Population

The first point to be ascertained from the eventual occupier is the total building population and whether this is likely to increase in the future.

If a definite population figure is unobtainable an assessment should be made from the net area and probable population density. Average population density can vary from about one person per 4 m² to one person per 20 m². It is essential, therefore, that some indication of the probable population density should be obtained from the building owner. If no indication is possible (a speculative development for example) population in the region of 5 m² per person for general office buildings is usually assumed.

31.1.6.2.3 Quantity of service

The quantity of service is a measure of the passenger handling capacity of a vertical transportation system. It is measured in terms of the total number of passengers handled during each five-minute period of the day. A five-minute base period is used as this is the most practical time over which the traffic can be averaged.

The recommended passenger handling capacity for various buildings is as follows:

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>Handling capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office – Diversified tenants</td>
<td>10 to 15 percent</td>
</tr>
</tbody>
</table>
31.1.6.2.4 Quality of Service

The quality of service on the other hand is generally measured by the passenger waiting time at the various floors. The following shall be the guiding factor for determining this aspect.

**Quality of Service or Acceptable Interval**

<table>
<thead>
<tr>
<th>No. of Floors</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 to 25 seconds</td>
<td>Excellent</td>
</tr>
<tr>
<td>30 to 35 seconds</td>
<td>Good</td>
</tr>
<tr>
<td>34 to 40 seconds</td>
<td>Fair</td>
</tr>
<tr>
<td>45 seconds</td>
<td>Poor</td>
</tr>
<tr>
<td>Over 45 seconds</td>
<td>Unsatisfactory</td>
</tr>
</tbody>
</table>

**Note** – For residential buildings longer intervals should be permissible.

31.1.6.2.5 Traffic peaks

The maximum traffic flow during the up peak period is usually used as a measure of the vertical transportation requirement in an office building. The employees of all offices are subject to discipline and are required to be at their place in time. Consequently, the incoming traffic flow is extremely high and the arrival time is over a short period.

Sometimes it becomes necessary to reduce the maximum traffic flow by staggering the arrival of the employees so that different groups arrive at different times. This reduces the peak and also the requirement of lifts. However, many organizations may object to staggering and prefer to have all employees arrive at the same time since it is claimed that staggering will affect the proper co-ordination of business.

31.1.6.2.6 Capacity

The minimum size of car recommended for a single purpose building is one suitable for a duty load of 884kg. Generally, for large office buildings cars with capacities up to 2,040 kg are recommended according to the requirements.

31.1.6.2.7 Speed

It is dependent upon the quantity of service required and the quality of service desired (see Clauses 31.1.6.2.3 and 31.1.6.2.4. Therefore, no set formulae for indicating the speed can be given. However, the following general recommendations are made:

<table>
<thead>
<tr>
<th>No. of Floors</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 5</td>
<td>0.5 to 0.75 m/s</td>
</tr>
<tr>
<td>6 to 12</td>
<td>0.75 to 1.5 m/s</td>
</tr>
<tr>
<td>3 to 20</td>
<td>1.5 m/s to 2.5 m/s</td>
</tr>
<tr>
<td>Above 20</td>
<td>2.5 m/s and above</td>
</tr>
</tbody>
</table>

31.1.6.2.8 Layout

The shape and size of the passenger lift car bears a distinct relation to its efficiency as a medium of traffic handling. A study of the most suitable proportions for these lifts reveal that the width of the lift well entrance is, in reality, the basic element in the determination of the best proportions. In other words, the width of the car is determined by the width of the entrance and the depth of the car is regulated by the loading per square metre permissible under this Code. Centre opening doors are more practicable and efficient entrance units for passenger lifts.

31.1.6.2.9 Determination of transport or handling capacity during the up peak

31.1.6.2.9.1 The handling capacity is calculated by the following formula:

\[
H = \frac{300 \times Q \times 100}{T \times P}
\]

where

- \(H\) = Handling capacity as the percentage of the peak population handled during a 5 minute period,
- \(Q\) = Average number of passengers carried in a car,
- \(T\) = Waiting interval in seconds, and
- \(P\) = Total population to be handled during peak morning period. (It is related to the area served by a particular bank of lifts).

The value of \(Q\) depends on the dimensions of the car. It may be noted that the car is not loaded always to its maximum capacity during each trip and, therefore, for calculating \(H\) the value of \(Q\) is taken as 80 percent of the maximum carrying capacity of the car.
The waiting interval is calculated by the following formula:

\[ T = \frac{RTT}{N} \]

\( T \) = Waiting interval in seconds,
\( N \) = Number of lifts, and
\( RTT \) = Round trip time, that is, the average time required by each lift in taking one full load of passengers from ground floor, discharging them in various upper floors and coming back to ground floor for taking fresh passengers for the next trip.

\( RTT \) is the sum of the time required in the following process:

a) entry of the passengers on the ground floor;
b) exit of the passengers on each floor of discharge;
c) door closing time before each starting operation;
d) door opening time on each discharging operation;
e) accelerating periods;
f) stopping and leveling periods;
g) periods of full rated speeds between stops going up; and
h) periods of full rated speeds between stops going down.

It is observed that the handling capacity is inversely proportional to the waiting interval which in turn is proportional to \( RTT \). Reducing the \( RTT \) of a lift from 120 to 100 increases its handling capacity by 20 percent.

The round trip time can be decreased not only by increasing the speed of the lift but also by improving the design of the equipment related to opening and closing of the landing and car doors, acceleration, deceleration, leveling and passenger movement. These factors are discussed below:

a) The most important factor in shortening the time consumed between the entry and the exit of the passengers to the lift car is the correct design of the doors and the proper car width. For comfortable entry and exit for passengers it has been found that the most suitable door width is 1000 mm and that of car width is 2000 mm.

b) The utilization of centre opening doors has been a definite factor in improving passenger transfer time, since when using this type of door the passengers, as a general rule, begin to move before the doors have been completely opened. On the other hand, with a side opening door the passengers tend to wait until the door has completely opened before moving.

The utilization of centre opening doors also favours the door opening and closing time periods. Given the same door speed, the centre opening door is much faster than the side opening type. It is beyond doubt that the centre opening door represents an increase in transportation capacity in the operation of a lift.

31.1.7.2.9.2 An example illustrating the use of the above consideration is given below:

Gross area per floor 1100 m\(^2\)
Net usable area per floor 950 m\(^2\)
No. of landings including ground 15

Assuming population density of 9.5 m\(^2\) per person

Probable population is

\[ P = \frac{14 \times 950}{9.5} \]

Upper floors 1400 persons

Taking 20 passengers lift with 2.5 m/s the calculated \( RTT \) is 165s

\[ Q = 20 \times 0.8 = 16 \]

a) Taking No. of lifts, \( N = 4 \)

\[ T = \frac{RTT}{N} = \frac{165}{4} = 41s \]

\[ H = \frac{300 \times Q \times 100}{T \times P} = \frac{300 \times 16 \times 100}{41 \times 1400} \]

\[ = 8.3 \text{ percent} \]
b) Taking No. of lifts, N = 6

\[ T = \frac{165}{4} = 27.6 \text{ s} \]

\[ H = \frac{300 \times Q \times 100}{T \times P} = \frac{300 \times 16 \times 100}{27.6 \times 1400} \]

= 12 percent

31.1.7.3 Quiet operation of lifts

The insulation of the lift machine and any motor generator from the floor by rubber cushions or by a precast concrete slab with rubber cushions, prevents transmission of most of the noise. In this connection, see also good practice and Part 29 Mechanical systems (Acoustics, sound Insulation and Noise Control) for some useful recommendations.

31.1.7.4 Positioning of lifts

A thorough investigation should be made for assessing the most suitable position for lift(s) while planning the building. It should take into account future expansions, if any. Though each building has to be considered individually for purposes of location of lifts, factors influencing the locations of passenger and goods lifts are given in Clause 31.1.6.4.2 to 31.1.6.4.4. The location of lifts may also conform to the travel distance requirements specified in this Code.

31.1.6.4.1 Arrangement of lifts

The lifts should be easily accessible from all entrances to the building. For maximum efficiency, they should be grouped near the centre of the building. It is preferably not to have all the lifts out in straight line and, if possible, not more than three lifts should be arranged in this manner. It has to be kept in mind that the corridor should be wide enough to allow sufficient space for waiting passengers as well as for through passengers.

31.1.6.4.1.1 In some cases when there are more than three lifts, the alcove arrangement is recommended. With this arrangement, the lift alcove lead off the main corridor so that there is no interference by traffic to other groups or to other parts of the ground floor. This arrangement permits the narrowest possible corridors and saves space on the upper floors. Walking distance to the individual lift is reduced and a passenger standing in the centre of the group can readily see all the lift doors and landing indicators. The ideal arrangement of the lifts depends upon the particular layout of the respective building and should be determined in every individual case. Some typical recommended arrangements are given in Fig. 1.

31.1.6.4.2 Passenger lifts

31.1.6.4.2.1 Low and medium class flats

Where a lift is arranged to serve two, three or four flats per floor, the lift may be placed adjoining a staircase, with the lift entrances serving direct on to the landings. Where the lift is to serve a considerable number of flats having access to balconies or corridors, it may be conveniently placed in a well ventilated tower adjoining the building.

31.1.6.4.2.2 Office buildings, hotels and high class flats

In general the arrangement as recommended in Clause 31.1.6.4.1 is to be followed. However, in case this is not possible, it is desirable to have at least a battery of two lifts at two or more convenient points of a building. If this is not possible, it is advisable to have at least two lifts side by side at the main entrance and one lift each at different clauses of the building for inter-communication. When two lifts are installed side by side, the machine room shall be suitably planned with sufficient space for housing the machine equipment. The positioning of lifts side by side gives the following advantages:

a) all machines and switch gear may be housed in one machine room;

b) the lifts can be inter-connected more conveniently from an installation point of view; and

c) greater convenience in service owing to the landing openings and each floor being adjacent.

31.1.6.4.2.3 Shops and departmental stores

Lifts in shops and stores should be situated so as to secure convenient and easy access at each floor.
31.1.6.4.2.4 For buildings with more than 12 floors, it is recommended to have a provision of 1 stretcher/service lift in addition to the passenger lifts.

31.1.7.4.2.5 For buildings with more than 12 floors, where passenger and service lifts are provided in one lobby it is recommended to have group control for all the lifts.

31.1.7.4.3 Goods lifts

The location of lifts in factories, warehouses and similar buildings should be planned to suit the progressive movement of goods throughout the buildings, having regard to the nature of position of the loading platforms, railway sidings, etc. The placing of a lift in a fume or dust laden atmosphere or where it may be exposed to extreme temperatures, should be avoided wherever possible. Where it is impossible to avoid installing a lift in an adverse atmosphere, the electrical equipment should be of suitable design and construction to meet the conditions involved.

31.1.7.4.3.1 Normally goods lifts have lower speeds than passenger lifts for the same travel because traffic conditions are less demanding, and more time is required for loading and unloading.

31.1.7.4.3.2 As loads for goods lifts increase in size and weight, so the operation of loading and unloading becomes more difficult. Therefore, it is usual to require greater accuracy of leveling as the capacity of the goods lift increases.

31.1.7.4.3.3 A large capacity goods lift at high speed is often a very uneconomical proposition. The inherent high cost is enhanced due to the very small demand for such equipment, much of which is custom made. The high capital cost of the lift, building work and electrical supply equipment usually shows a much smaller return as an investment than more normal sizes of lifts.

31.1.7.4.4 Hospital bed lifts

Hospital bed lifts should be situated conveniently near the ward and operating theatre entrances. There shall be sufficient space near the landing door for easy movement of stretcher.

It is convenient to place the passenger lifts in a hospital, near the staircases.

31.1.7.4.5 Personnel and Material Hoists

Personnel and material hoists shall be designed utilizing an approved method that accounts for the conditions imposed during the intended operation of the hoist device. The design shall include, but is not limited to, anticipated loads, structural stability, impact vibration, stresses and seismic restraint. The design shall account for the construction, installation, operation and inspection of the hoist tower, car, machinery and control equipment, guide members hoisting mechanism. Additionally, the design of the personnel hoists shall include provisions for the field testing and maintenance that will demonstrate that the hoist device functions in accordance with the design. Field tests shall be conducted upon the completion of an installation or following a major alteration of a personnel hoist.

31.1.6.5 Structural considerations

31.1.6.5.1 Lift well enclosures, lift pits, machine rooms and machine supports besides conforming to the essential requirements given in Clause 31.1.4, should form part of the building construction and comply with the lift manufacturer’s drawings.

31.1.6.5.2 Machine room

Floors shall be designed to carry a load of not less than 350 kg/m² over the whole area and also any load which may be imposed thereon by the equipment used in the machine room or by any reaction from any such equipment both during periods of normal operation and repair.

31.1.6.5.3 The side wall of the lift well may be made of reinforced concrete at least 150 mm thick so as to provide satisfactory anchoring arrangement for fixing. Reference shall also be made to Part 17 Structural Loads and Design.

31.1.6.5.4 The total load on overhead beams shall be assumed as equal to all equipment resting on the beams plus twice the maximum load suspended from the beams.

31.1.6.5.5 The factor of safety for all overhead beams and supports based on ultimate strength of the material and load in accordance with
Clause 31.1.6.5.4 shall be not less than the following:

For steel 5
For Reinforced Concrete 7

The deflection of the overhead beams under the maximum static load calculated in accordance with above shall not exceed 1/1500 of the span.

31.1.6.6 Access to machine room and lift pits

31.1.6.6.1 Access to machine room above a lift well may be either from the roof or by an internal staircase with a proper arrangement for fixing.

31.1.6.6.2 Access between a secondary floor and a machine room may be by ladder. Where a machine room entrance is less than 1.5m above or below the adjacent floor or roof surfaces, a substantial permanently attached ladder may be used. Ladders shall be fixed at least 150mm clear of any wall, beam or obstruction and shall extend at least to the landing level. Above the landing level and for a height of at least 1.15m, either the ladder stringers shall be extended or suitable hand grips shall be provided.

31.1.6.6.3 Where the machine room entrance is 1.5m or more above or below the adjacent floor or roof surface, access shall be provided by means of stairs in accordance with the requirements given in Clause 31.1.6.6.3.1 to 31.1.6.6.3.6.

31.1.6.6.3.1 The angle of inclination of the stair shall not exceed 50° from the horizontal and the clear width of the stair shall be not less than 600 mm.

31.1.6.6.3.2 The trend shall have a non-slip surface which shall be not less than 150 mm wide for open stair construction and not less than 20 cm wide for closed stair construction.

31.1.6.6.3.3 The rise of the stair shall not exceed 250mm.

31.1.6.6.3.4 A hand rail shall be provided on the outer stringer of all stairways fixed at a convenient height, but not less than 500mm high measured vertically from the nosings, and not less than 1m high on landings and platforms. Such hand rail shall have at least 50mm clearance between nearest permanent object at the corresponding side of the stair.

31.1.6.6.3.5 Headroom clearance of not less than 2m measured from the nosings of the stairway, shall be provided on every stairway.

31.1.6.6.3.6 Heights of stairs over 5m in length shall be provided with intermediate landings.

Note – Where compliance with any of the requirements specified in Clause 31.1.6.6.1 to 31.1.6.6.3 is impracticable, applications for variation shall be made to the Authority having jurisdiction, who may, vary such requirements.

31.1.6.6.4 Access to a machine room via the lift well shall be prohibited.

31.1.6.6.5 The lift pit should be capable of being examined by a separate access. In the case of a battery of two lifts, it is possible to examine the lift pit through the adjoining one.

31.1.6.7 Fire protection

To prevent fire from spreading by means of the lift well, lift well enclosures shall conform to the requirements given in this Code. The machine room should be constructed of a suitable grade of fire resisting material and precautions should be taken to minimize spread of fire from the machine room into the lift well.

31.1.6.8 Requirements for fireman’s lift

31.1.6.8.1 For buildings having height of 15m or more at least one lift shall meet the requirements of fireman’s lift as given in Clause 31.1.6.8.2.

31.1.6.8.2 The fireman’s lift shall have the following minimum requirements:

a) Lift car shall have floor area of not less than 1.44 square metres. It shall also have a loading capacity of not less than 544 kg (8 persons).

b) Lift landing doors shall have a minimum of fire resistance of one hour.

c) Doors shall be of automatic operation for car and landing.
31.1.6.8.3 Fireman’s lifts in a building having more than 15m or more in height, shall work at or above the speed of 1.0 m/s so as to reach the top floor from ground level within one minute.

31.1.6.8.4 Operation requirements of fireman’s lift

a) A two position switch at evacuation floor (normally main entrance floor) (ON/OFF), and

b) Buzzer and ‘Fireman’s Lift’ – light in car.

31.1.6.8.4.1 Sequence of operation

a) Return to evacuation floor (Phase 1)

1) Shall start when the switch at the evacuation floor is turned to the “ON” position or the signal from smoke detector (if provided by the Building Management System) is on. All lift(s) controlled by this switch shall cancel all existing car calls and separate from landing calls and no landing or car calls shall be registered. The buzzer and ‘fireman’s lift’ light shall be turned on. All heat and smoke sensitive door reopening devices shall be rendered inoperative.

2) If the lift is travelling towards the evacuation floor, it shall continue driving to that floor.

3) If the lift is travelling away from the evacuation floor, it shall reverse its direction at the nearest possible floor without opening its doors and return non-stop to the evacuation floor.

4) If the lift is standing at a floor other than the evacuation floor, it shall close the doors and start travelling non-stop to the evacuation floor.

5) When at the evacuation floor, the lift shall park with doors open.

6) The buzzer is turned off after this return drive.

b) Fireman’s service (Phase 2)

The phase 2 operation of the lift shall be as defined below:

1) The phase 2 is started after phase 1, if the switch is “ON”

2) The lift does not respond to landing calls but registers car calls. All heat and smoke sensitive door reopening devices are rendered inoperative.

3) When the car call button is pressed the doors start closing. If the button is released before the doors are fully closed, they re-open. The car call is registered only when the doors are fully closed.

4) After registering a car call the lift starts driving to the call. If more than one car call is registered, only the nearest call is answered and the remaining calls will be cancelled at the first stop.

5) At the floor the doors are opened by pushing the door open button. If the button is released before the doors are fully open, they re-close.

6) The lift returns to normal service when it stands at the evacuation floor with doors open and the switch is “OFF”.

31.1.6.9 Supply cables and switches

Each lift should be provided with a main switch or circuit breaker of a capacity determined by the lift manufacturer and the incoming supply cable should terminate in this switch. For a single lift, this switch should be fixed adjacent to the machine room common to more than one lift; each main switch should be conveniently situated with respect to the lift it controls. Switches and fuses (which may form part of a distribution switch-board) should be provided for isolating the supply cables to the machine room.

31.1.6.10 The detailed design considerations for different types and selection of the lifts shall be done in accordance with good practice.

31.1.7 Power and control systems

31.1.7.1 Feature associated with power systems

31.1.7.1.1 Industrial switchgear

Switchgear for controlling lift power systems is characterized by its high duty cycle and its high rupturing capacity. Switchgear must be robust enough and shall be so designed as to withstand the high duty cycle and high rupturing
capacity introduced during the operation of the lifts.

31.1.7.1.2 Leveling accuracy

The leveling tolerances in accordance with good practice are those which can be reasonably expected between no load and full load in either direction.

Where greater leveling accuracy is required, careful examination should be made to see whether such increased precision is justified or practical. Advice should also be obtained, as additional apparatus and cost may be involved, and in some cases the requirement may not be practicable.

31.1.7.1.3 Corrective leveling

This should only be used when it is impossible otherwise to achieve the required leveling tolerances or on long travel lifts to maintain the required leveling tolerances during loading and unloading.

31.1.7.1.4 Leveling with variable voltage

A variable voltage system is one using continuous regulation which minimizes speed differences due to load variation. Therefore, the actual leveling speed is of less importance than the general refinement of its regulation control. In fact, no leveling speed as such may be identifiable.

31.1.7.1.5 Overload tests

A lift is designed to operate and transport the contract load at the required duty cycle, and should not by intention or habitually be used to carry overloads. During test as a safeguard to cover variable supply and temperature conditions, a lift is checked for the car to complete one round trip with contract load plus 10 percent at nominal supply voltage and nominal ambient temperature. There is also a static test with contract load plus 35 percent to check that the brake will sustain the car.

It is unnecessary to specify an additional overload test or capacity and in fact it is detrimental to the normal running efficiency and safety of the lift to do so.

31.1.7.1.6 Occasional extra load

It is not good practice to request that a lift should be designed to carry an occasional extra load. It is tantamount to specifying an excessive overload test which is detrimental to the normal running efficiency and safety of the lift.

31.1.7.2 Description of operation systems

31.1.7.2.1 Methods of control systems

The methods of control systems are as follows:

a) collective control (see Clause 31.1.7.2.3);

b) single push button collective control (see Clause 31.1.7.2.4);

c) down collective control (see Clause 31.1.7.2.5);

d) directional collective control for one car (see Clause 31.1.7.2.6);

e) directional collective control for two or three cars (see Clause 31.1.7.2.7);

f) group supervisory control (see Clause 31.1.7.2.8).

Features of control systems are described in Clause 31.1.7.3.

31.1.7.2.2 Automatic push button operation

Automatic control is a method of operation by which a momentary pressure on a push button sets the car in motion and causes it to stop automatically at any required lift landing. This is the simplest control system and it is sometimes referred to as push button control.

A car answers a landing or car call whichever is actuated first by momentary pressure provided the lift is not in use. Momentary pressure of a car push button will send the car to the designated floor. The car always responds to a car push button in preference to a landing push button.

With this type of control, a RED landing signal light or direction arrow indicates that the car is in use that is the lift is travelling.

This type of control is recommended for the following applications:
a) a single passenger lift serving up to 4 floors;

b) good lifts serving any number of floors where it is usually the most suitable form of control.

For special purposes, the following two systems may be considered:

a) Dispatch from landings as an additional feature for a goods lift with manually operated doors. The call is registered by pressing the car push button and when the doors are closed the car will travel to the designated floor.

b) Automatic with attendant control as an additional feature on goods lifts with a key operated switch in the car to transfer the control from normal automatic to attendant operation. There is also a visual call indicator with buzzer in the car to indicate to the attendant the landing floors at which push buttons have been pressed when the car is under attendant control.

31.1.7.2.3 Collective control

Collective control is a generic term for those methods of automatic operation by which calls made by pressing push buttons in the car and at lift landings are registered and answered by the car stopping in floor sequence at each lift landing for which calls have been registered irrespective of the order in which the calls have been made, and until all calls have had attention.

Collective control of any form is usually not suitable for goods lifts except where loading is not expected to fill the car and additional loads can be taken at other stops.

31.1.7.2.4 Single push button collective control

Single push button collective control has a single push button at each landing. It is recommended, as the direction in which it is desired to travel cannot be registered by the intending passenger.

31.1.7.2.5 Down collective control

Down collective is a control system where landing calls are registered from a single push button, irrespective of the car being in motion or the landing door being open and calls are stored until answered. Any number of car calls can be registered and the car will stop in sequence in the down direction at each of the designated floors. The car will travel in the up direction to the highest call registered stopping only in response to car calls. It will then travel downwards answering calls in floor sequence. If only one call has been registered the car travels to the floor of call.

The system is suitable where there is traffic between the ground and upper floors only and no inter floor traffic. Two or three car banks have interconnected control.

With this type of control the following signals are included:

a) a landing signal light indicates that the call has been registered and will be answered;

b) illuminated car position indicator above car entrance.

31.1.7.2.6 Directional collective control for one car

Directional collective control for one car is a control system having UP and DOWN push buttons at intermediate landings whereby the call is registered for the intended direction of travel. Calls from the car or landing push buttons are registered and stored until answered. The car will answer calls in floor sequence in one direction of travel. Calls for the opposite direction of travel are answered when the direction of travel is reversed.

This system is suitable for single lifts serving 4 or more floors with interfloor traffic, such as small office blocks, hotels and blocks of flats.

With this type of control the following signals are included:

a) a landing signal light for each landing push button indicates that the call has been registered and will be answered;

b) illuminated car position indicator above the entrance in the car;
c) arrow shaped signal lights in the back of the car or on the landing to indicate to the entering person in which direction the car is going to depart.

31.1.7.2.7 Directional collective control for two or three cars

Directional collective control for two or three cars is a system covering a control in which the two or three cars in a bank are interconnected. One push button unit with UP and DOWN push buttons or floor buttons (in case of car control from floor) is required at each landing and the call system is common to all lifts. If for architectural balance, in the case of a three-car bank, extra push button units are required, these should be specified. Each landing call is automatically allocated to the best placed car. The control is designed so that cars are effectively spaced and thus give even service. When a car reaches the highest floor to which there is a call, its direction of travel is automatically reversed when it next starts. One or more cars will return to the parking floor.

Automatically bypassing of landing calls when a car is fully loaded is an essential feature for three-car banks. It is also necessary for two-car banks in offices. Other cars will continue to provide service to all floors.

When three-car banks serve 7 or 8 floors and over, some form of automatic supervisory control (see Clause 31.1.7.2.8) is generally necessary in the interest of efficiency.

With this type of control the following signals are included:

a) a landing signal light for each landing push button to indicate that the call has been registered and will be answered;

b) illuminated car position indicator above the entrance in the car;

c) arrow-shaped single lights in conjunction with an audible single stroke gong or an indication on the landing call push button station above each landing entrance to indicate to the waiting person(s) which car is going to stop and in which direction it will continue its course.

31.1.7.2.8 Group supervisory control

A bank or group of intensive traffic passengers lifts requires a supervisory system to co-ordinate the operation of individual lifts which are all on collective control and are interconnected.

The very nature of intensive service calls for a sophisticated automatic supervisory control system so as to match the speed capacity of these lifts.

The supervisory system regulates the dispatching of individual cars and provides service to all floors as different traffic conditions arise minimizing such unproductive factors as idle cars, uneven service and excessive waiting time. The system will respond automatically to traffic conditions such as UP and DOWN peaks, balanced or light traffic and provides for other specialized features.

If desired, a master station can be provided in the lift lobby which gives by indicators, visual information regarding the pattern under which the system is operating. Where the system is based on a definite programme, control means are provided for altering the type of traffic programme. There are other facilities, such as the removal of any lift from service.

31.1.7.3 Features of operation systems

31.1.7.3.1 Car preference

Sometimes it is necessary to give a special personal service or a house service. When this service is required and for whatever purpose, it should be specified as 'car preference' by a key operated switch in the car. The operation is then from the car only and the doors remain open until a car call is registered for a floor destination. All landing calls are bypassed and car position indicators on the landing for this lift are not illuminated. The removal of the key when the special operation is completed restores the control to normal service.

31.1.7.3.2 Landing call automatic bypass

For collective operation, automatic bypassing of landing calls can be provided. This device will bypass landing calls when a car is fully loaded but the calls are not cancelled.
31.1.7.3.3 Motor generator shut down

Lifts controlled by variable voltage system automatically shut down when subject to an over-riding control which puts them out of service under certain conditions; for example, no demand for lift service. They are automatically put back into service as required.

31.1.7.3.4 Basement service

For lifts with collective control when service is required below the main parking floor, which is usually the ground floor, to a basement and/or a sub-basement, the lift manufacturer should be informed of the type of service required, as special technical considerations are then usually necessary.

31.1.7.3.5 Hospital service

Lifts for carrying beds and stretchers require a car preference switch so that an attendant can have complete control of the car when required. This requirement should be specified as ‘car preference’ and it will function as described in Clause 31.1.7.3.1. Otherwise such lifts can have the same control systems as for normal passenger lifts, the choice depending on the number of floors served, the service required and the number of lifts.

31.1.7.3.6 Manually operated doors (without closers)

A ‘door open’ alarm should be provided to draw attention to a car or landing door which has been left open.

31.1.7.3.7 Automatically power closed doors

For passenger operation when the car arrives at a landing the doors will automatically open and then close after lapse of a time interval. This time interval can be overruled by the pressure of a push button in the car to give instant door closing.

An ‘open door’ push button is provided in the car to reverse closing motion of the doors or hold them open.

31.1.7.3.8 Controlled power closed doors

When there are conditions that particularly affect the safety of passengers or damage to vehicles or trucks, the closing of the doors should only be made by the continuous pressure of push buttons in the car or on landings.

A ‘door open’ alarm should be provided to draw attention to a car or landing door which has been left open. This means of operation is required for some forms of goods lifts.

31.1.7.3.9 Safe operation of doors

The safety of passengers passing through lift entrances is fully covered by the provision of good practice. No modification of these provisions should be specified.

31.1.7.3.10 Director service

There are many forms of giving special service for individuals, but they should always be avoided. They range from key operated switches at preferred landings to the complete segregation of one out of a bank of lifts. It is obvious that any preferential treatment of this nature can seriously jeopardize the efficiency of the service as a whole. When a bank of say three lifts is installed to meet the anticipated traffic requirements and then, when the building is occupied, one lift is detached permanently for directors’ service, the traffic handling can be reduced by a half rather than a third.

When preferential service is imperative, then the car preference feature should be available.

31.1.7.3.11 Indication of car arrival

As all lift cars are illuminated when available (in service). It is recommended that this illumination be used to signal the arrival of a car at a landing in preference to special signals such as ‘LIFT HERE’ signs since signal lamps can fail when the lift is still operating satisfactorily.

The following is the practice adopted for vision panels in doors:

a) for lifts with manually operated car and landing doors, vision panels are provided in all doors;

b) for lifts with power operated car doors and manually operated landing doors, vision panels are provided in the landing doors only;

c) for lifts with automatically opened car and landing doors, no vision panels are required; and
d) when vision panels are provided they should comply with the requirements of good practice.

31.1.7.3.12 Service switches
When switches are provided to take cars out of service, that is because the remaining cars in the group can cater for the required passenger traffic, it is essential that such switches should not stop the fireman’s control from being operative in the event of the lift being designated as a fireman’s lift. Service switches should not be confused with maintenance switches which are only used when it is dangerous to attempt to operate the lift because maintenance work is actually in progress. A control station fitted on top of the car is regarded as a maintenance switch.

31.1.7.3.13 Fire switch
When required by the Ghana National Fire Service, a fire switch has to be provided; the function of which is to enable the fire authority to take over the complete control of one or more lifts in an installation.

31.1.7.3.14 Push buttons and signals
It is most important that the purpose of every push button and signal should be clearly understood by all passengers.

31.1.7.3.15 In public places where blind persons are expected to use the lifts it is recommended to provide Braille buttons.

31.1.7.4 Electrical installation requirements
31.1.7.4.1 General
Good practice states the requirements for main switches and wiring with reference to relevant regulations. The lift manufacturer should specify, on a schedule, particulars of full load current, starting current, maximum permissible voltage drop, size of switches and other details to suit requirements. For multiple lifts, a diversity factor may be used to determine the cable size and should be stated by the lift manufacturer.

It is important that the switches at the intake and in the machine room which are provided by the electrical contractor are the correct size, so that correctly rated HRC fuses can be fitted. No form of ‘NO VOLT’ trip relay should be included anywhere in the power supply of the lift.

a) Power supply mains – The lift sub-circuit from the intake room should be separate from other buildings. Each lift should be capable of being isolated from the mains supply. This means of isolation should be lockable.

b) For banks of interconnected lifts, a separate sub-circuit is required for the common supervisory system. In order that any car may be shut down without isolating the supervisory control of remainder.

c) Lighting – Machine rooms and all other rooms containing lift equipment should be provided with adequate illumination and with a switch fixed adjacent to the entrance. At least one socket outlet, suitable for lamps or tools, should be provided in each room.

The supply to the car light should be from a separate circuit, and controlled by a switch in the machine room. For multiple lifts with a common machine room, a separate supply should be provided for each car. The car lighting supply should be independent of the power supply mains. Any plug should be provided with a light, the switch for which should be in the lift well, and accessible from the lower terminal floor entrance.

When the alarm system is connected to a transformer or trickle charger, the supply should be taken from the machine room lighting.

31.1.7.4.2 Electric wiring and apparatus
31.1.7.4.2.1 All electrical supply lines and apparatus in connection with the lift installation shall be so constructed and shall be so installed, protected, worked and maintained that there may be no danger to persons therefrom.

31.1.7.4.2.2 All metal casings or metallic coverings containing or protecting any electric supply lines of apparatus shall be efficiently earthed.

31.1.7.4.2.3 No bare conductor shall be used in any lift car as may cause danger to persons.
31.1.7.4.2 The terminal for the earthing of the metallic cases and covers of door interlocks, door contacts, call and control buttons, stop buttons, car switches, limit switches, junction boxes and similar electrical fittings which normally carry only the control current (such terminal being one specially provided for this purpose), and the earth conductor should be appropriately sized in accordance with good practice.

The size of earthing conductor shall be in accordance with Part 28 Electrical Systems and Allied Installations.

31.1.7.4.3 The earthing conductor shall be secured to the earthing terminal in accordance with the recommendations made in good practice and also in conformity with the latest provisions of ECG Act and Rules indicated thereunder from time to time.

31.1.7.4.4 The exposed metal parts of electrical apparatus installed on a lift shall be sufficiently bonded and earthed.

31.1.7.4.5 Where a screwed conduit screws into electric fittings carrying control current making the case and cover electrically continuous with the conduit, the earthing of the conduit may be considered to earth the fitting. Where flexible conduit is used for leading into a fitting, the fitting and such length of flexible conduit shall be effectively earthed.

31.1.7.4.6 One side of the secondary winding of bell transformers and their cases shall be earthed.

31.1.7.4.7 Where there are more than one lift in a building, there should be a separate earth pit for the lifts.

31.1.7.5 Building management systems – interface for lifts

31.1.7.5.1 Where more than three lifts are provided in a building and especially when these are provided at different locations in the building, a form of central monitoring may be provided. Such central monitoring may be through a Building Management Systems, if provided in the building or through a display panel.
31.1.7.5.2 The following signals should be given to the building management interface from each lift:

a) alarm button in car;

b) door moving information;

c) power on information; and

d) lift position information.

31.1.7.5.3 Each of these signals shall be provided through a potential free contact located in the lift machine room. The contacts shall be rated for 230V ac/1A or 24V dc/1A. A pair of wires should be used for each potential contact.

31.1.7.5.4 The wiring between lift machine room to Building Management Systems shall be planned and carried out by the builder along with other wiring in the building.

31.1.7.5.5 The Building Management System should ensure that any position information is read only when the lift is not moving (lift moving information) or is capable of reading several times to detect a stable state.

In addition to the signals above the following signals may be added if required for the benefit of monitoring the lift performance:

a) A summary fault output to indicate a lift in fault condition, which prevents the lift from providing service. This summary fault condition shall include the most common faults such as safety circuit open.

b) Service or inspection mode.

c) Attendant mode.

d) Fire mode.

e) Doors opening.

f) Doors closing.

g) Lift moving up.
(In combination with lift moving and lift moving up information, lift moving down information can be sensed by the Building Management Systems).

h) Door reopen request (summary of door open, light curtain, photocell, safety edge signals).

31.1.7.5.6 Where it is desired that it should be possible to control the lift from Building Management Systems, the following control signals can be provided:

a) normal to service/inspection mode change over;

b) fault accept/rest input (using this input, the lift controller may be allowed to clear an existing fault if this is otherwise safe. It will be decided by the lift manufacturer as to what faults can be cleared);

c) car call to top most floor and bottom most floor of each lift.

Where such control inputs are provided, it should be with a pass word and log in feature that allows one to determine who has used these inputs and at what time. Always such inputs should be through authorized persons only. The Building Management Systems should make all changeovers effective only when the lift is not moving.

31.1.7.5.7 Control inputs from Building Management Systems should be through a potential free contact capable of carrying 24V dc/1A or 230V ac/1A. The wiring should be terminated in each lift machine room.

31.1.8 Conditions for optimum practice

31.1.8.1 Lift entrance operation

31.1.8.1.1 General

Every lift journey involves two horizontal movements, in and out of the car, to one vertical movement. The type of door, and the operation of the doors, play a main part in the service given, and should receive careful consideration.

31.1.8.1.2 Goods traffic

Most types of goods traffic require relatively longer loading and unloading times and manual doors are frequently used for economy and simplicity.

Power operation can be applied, especially for large entrances, to give automatic opening: the doors then always open fully, reducing the risk of damage. For many types of goods traffic, it is preferable for closing though powered, to be controlled by continuous pressure button, rather than being automatically imitated.
For heavy duty lifts, a power operated vertically sliding door is preferred, this can be made extremely robust, and is capable of extension to very large entrances.

31.1.8.2 Planning at works and on site

Lift equipment will normally receive a protective coat of paint at works before dispatch to site. Further painting of lift may be necessary and is normally in the form of a finishing coat and can take place on site. Alternatively, the further painting of the equipment may be carried out at works as a finishing coat with normal touching up after site erection as may be necessary. Any additional painting, due to site conditions during erection and/or final operating conditions in the premises, is subject to negotiation between the lift manufacturer and the purchaser.

Decorative finishes are a subject for separate negotiation.

31.1.8.3 Special environments

Standard equipment is suitable for use inside normal residential, commercial and industrial buildings but when unusual environments are likely to be encountered, the advice of the lift manufacturer should be sought at the earliest possible stage to enable the most economically satisfactory solution to be found. Special mechanical protection and/or electrical enclosures may be necessary as well as compliance with statutory or other regulations and with the purchaser's particular requirements, which should be fully considered at the time of enquiry. Examples of situations which necessitate special consideration are:

a) exposure to weather, for example, car parks;
b) low temperatures, for example, cold stores;
c) high temperatures, for example, boiler plant;
d) hosing-down for example, for hygiene or decontamination;
e) corrosive atmosphere, for example, chemical works;
f) dusty atmospheres, for example, gas plant;
g) explosive and inflammable atmosphere, for example gas plants, and petroleum and polyester industries.

31.1.8.4 Ventilation of machine rooms

Machine rooms shall be ventilated. They shall be such that the motors and equipment as well as electric cables etc. are protected as far as possible from dust, harmful dusts and humidity. The ambient temperature in the machine room shall be maintained between 50°C and 40°C.

31.1.8.5 Lighting and treatment of walls, floors, etc.

31.1.8.5.1 All machine rooms should be considered as plant space, and conditions provided to permit reliable operation of electrical switchgear and rotating machinery, and be conducive to good maintenance.

Lighting should be provided to give at least 200 lux around the controller and machine. The machine room walls, ceiling and floor should be faced in dust-resisting materials, tiles, etc. or painted as a minimum to stop dust circulation which otherwise could damage rotating machinery and cause failure of switchgear. Machine rooms should also be weatherproof and if ventilation louvres are provided they should be designed and sited to prevent storm water being driven through or to the apparatus.

31.1.8.5.2 Lift wells should be constructed to be weatherproof and of a dust free surface material or should be painted to minimize dust circulation on to moving apparatus and from being pumped by the car movement into machine rooms or on to landings.

Sufficient number of light points should be provided in the lift shaft for proper illumination.

31.1.8.5.3 Should a lift entrance open out into an area exposed to the weather, the entrance should be protected by a suitable canopy and the ground level sloped up to the entrance to prevent rain or surface drainage from entering the lift well through the clearances around the landing doors. Any push buttons so enclosed should be of weatherproof type.
31.1.8.6 Stairwell enclosures

The location of lifts in stairwells is not recommended.

The use of stair stringers for fixing of guides normally involves extensive site measurement in order to fabricate purpose-made brackets. The resulting attachments are often unreliable and lacking in robustness. For stairwells of normal width, the span required for the lift machine support beams is excessive and unless uneconomic clauses are used, the deflections under varying load adversely affect the motor of the lift.

The necessary provision of suitable continuous enclosures can be very expensive.

31.1.8.7 Hand-winding release procedure and indication

The release procedure by hand-winding should only be carried out in an emergency and by authorized persons who have received the necessary instruction because it is dangerous for any other persons to attempt to do so.

Before attempting to move the car, it is imperative that any person in the car be warned of the intention to move the car and that they do not attempt to leave the car until they are advised that it is safe to do so. Any failure to carry out this precaution may render the person concerned guilty of negligence should an accident occur.

Before attempting to hand-wind the lift machine, it is vital that the supply is switched off at the main switch.

It is usually necessary to have two persons in the machine room; one to operate the brake release and the other to carry out the hand-winding. The exceptions are small lift machines where the hand-winding can be easily controlled by one man and larger machines which need two men to operate the hand-winding alone, with an additional man to control the brake release.

If the car is stuck in the lift well and cannot be moved when an attempt is made to move it in a downward direction, then no attempt at hand-winding should be made because the car safety gear may have set. Any further procedure should be carried out under the instruction of a qualified lift mechanic.

Provided the car is free to be moved in the downward direction, then it should be hand wound to the nearest floor. There is a preference to move the car in a downward direction. However, this may not always be practical owing to the distance involved and the time taken to complete the movement. In addition the amount of out of balance load on the counterweight side, due to the size of car and the small number of persons inside it, it may make it necessary to wind the car upwards. In the case of higher speed lifts, the direction of hand-winding will usually be governed by the effort required to move the car because of the absence of a large gear reduction ratio.

It is essential that all detail operations be carried out according to the manufacturer’s instructions for the lift concerned and these should be clearly stated and permanently displayed in the form of a notice in the machine room.

31.1.9 Escalators

31.1.9.1 Escalators are deemed essential where the movement of people, in large numbers at a controlled rate in the minimum of space, is involved, for example, railway stations, airports, etc. In exhibitions, big departmental stores and the like, escalators encourage people to circulate freely and conveniently.

31.1.9.1.1 As the escalators operate at a constant speed, serve only two levels and have a known maximum capacity, the traffic study is rather easy. Provided the population to be handled in a given time is known, it is easy to predict the rate at which the population can be handed.

For normal peak periods, the recommended handing capacities for design purposes should be taken as 3200 to 6400 persons per hour depending upon the width of the escalator.

The number of person that may be theoretically carried by the escalator in 1 hour can be calculated as follows:
a) For determination of theoretical capacity it is assumed that one step with an average depth of 0.4m can carry 1 person for a step width of 0.6m, 1.5 persons for a step width of 0.8m and 2 persons for a step width of 1.0m.

b) The theoretical capacity then is:

$$3600 \times \left( \frac{\text{rated speed in m/s} \times K}{0.4} \right)$$

where $K = 1, 1.5, \text{ or } 2$ for 0.6, 0.8 ad 1.0m step widths.

c) Some values calculated as per the above are:

<table>
<thead>
<tr>
<th>Step Width</th>
<th>Theoretical Capacity in Persons/hour</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.5 m/s</td>
</tr>
<tr>
<td>0.6 m</td>
<td>4500</td>
</tr>
<tr>
<td>0.8 m</td>
<td>6750</td>
</tr>
<tr>
<td>1.0 m</td>
<td>9000</td>
</tr>
</tbody>
</table>

31.1.9.2 Essential requirements

31.1.9.2.1 Angle of inclination of an escalator from the horizontal shall not exceed 30°, but for rises not exceeding 6 m and rated speed not exceeding 0.5 m/s the angle of inclination is permitted to be increased up to 35°.

31.1.9.2.1.1 The rated speed of the escalator shall not exceed 0.75 m/s for an angle of inclination up to 30° and 0.5 m/s for an escalator with an angle of inclination of more than 30° but within 35°.

31.1.9.2.2 The horizontal distance (measured at right angles to the direction of travel) between the balustrade interior paneling at lower points shall be equal to or less than the horizontal distance measured at points higher up. The maximum distance between the balustrade interior paneling at any point shall be smaller than the distance between handrails.

31.1.9.2.3 The parts of the balustrade facing the steps shall be smooth. Covers or strips not in the direction of travel shall not project more than 3 mm. They shall be sufficiently rigid and have rounded or beveled edges. Cover or strips of such nature are not permitted at the skirting.

Cover joints in the direction of travel (in particular between the skirting and balustrade interior paneling) shall be arranged and formed in such a manner that the risk of trapping is reduced to a minimum.

Gaps between interior panels of the balustrade shall not be wider than 4 mm. The edges shall be rounded off or beveled. The balustrade interior paneling shall have adequate mechanical strength and rigidity. When a force of 500N is applied at any point of the paneling at right angles on a area of 2500 mm², there shall be no gap greater than 4 mm and no permanent deformation (setting tolerances are permitted).

The use of glass for balustrade interior paneling is permitted with the approval of the Authority having jurisdiction; further, provided it is splinter free one layer safety (tempered) glass and has sufficient mechanical strength and rigidity. The thickness of the glass shall not be less than 6 mm.

31.1.9.2.3.1 There shall be no abrupt changes in the width between the balustrades on the two sides of the escalator. Where a change in width is unavoidable, such change shall not exceed 8 percent of the greatest width. In changing the direction of the balustrades resulting from a reduction in width, the maximum allowable angle of change in balustrade shall not exceed 15° from the line of the escalator travel.

31.1.9.2.3.2 Where the skirting of the escalator is placed beside the steps, the horizontal clearance shall not exceed 4 mm at either side and 7 mm for the sum of the clearances measured at both sides at two directly opposite points.

31.1.9.2.3.3 Where the building obstacles can cause injuries appropriate preventive measures shall be taken. In particular, at floor interclauses and on criss-cross escalators, a vertical obstruction of not less than 0.3 m in height (not presenting any sharp cutting edge, for example as an imperforate triangle) shall be placed above the balustrade decking. It is not necessary to comply with this requirement when the distance between the centerline of the handrail and any obstacle in equal to or greater than 0.5m.
For escalators arranged adjacent to one another either parallel or criss-cross, the distance between the edges of the handrails shall not be less than 120 mm.

31.1.9.2.4 Handrails

31.1.9.2.4.1 Each balustrade shall be provided with a handrail moving in the same direction and at substantially the same speed as the steps.

31.1.9.2.4.2 Each moving handrail shall extend at normal handrail height not less than 300 mm beyond the line of points of comb-plate teeth at the upper and lower landings.

31.1.9.2.4.3 Hand or finger guards shall be provided at the points where the handrail enters the balustrade.

31.1.9.2.4.4 The width of the handrail shall be between 70 mm and 120 mm. The distance between the handrail and the edge of the balustrade shall not exceed 50 mm. The distance between the centerline of handrails shall not exceed the distance between the skirtings by more than 0.45 m.

31.1.9.2.5 Step treads

31.1.9.2.5.1 The step depth in the direction of travel shall not be less than 0.38 m.

31.1.9.2.5.2 The surface of the step treads shall have grooves in the direction of movement, with which the teeth of the combs mesh. They shall be sensibly horizontal in the usable area of the escalator.

The width of the grooves shall be at least 5 mm and not exceed 7 mm. The depth of the grooves shall not be less than 10 mm. The web width shall be at least 2.5 mm and not exceed 5 mm.

31.1.9.2.6 Landing

The landing area of escalators shall have a surface that provides a secure foothold for a minimum distance of 0.85 m measured from the root of the comb teeth. Exempted from this are the combs.

31.1.9.2.7 Compliance

There shall be a comb-plate at the entrance and at the exit of every escalator. The comb-plate teeth shall be meshed with and set into the splots in the tread surface so that the points of the teeth are always below the upper surface of the treads. Comb-plates shall be adjustable vertically.

31.1.9.2.8 Trusses or girders

The truss or girder shall be designed to safely sustain the steps and running gear in operation. In the event of failure of the track system it shall retain the running gear in its guides.

31.1.9.2.9 Step wheel tracks

This shall be designed to prevent displacement of steps and running gear if a step chain breaks.

31.1.9.2.10 Driving machine, motor and brake

31.1.9.2.10.1 The driving machine shall be connected to the main drive shaft by toothed gearing, a coupling, or a chain.

31.1.9.2.10.2 An electric motor shall not drive more than one escalator.

31.1.9.2.10.3 Each lift shall be provided with an electrically released, mechanically applied brake capable of stopping the up or down travelling escalator with any load up to rated load. This brake shall be located either on the driving machine or on the main drive shaft.

Where a chain is used to connect the driving machine to the main drive shaft, a brake shall be provided on this shaft, it is not required that this brake be of the electrically released type if an electrically released brake is provided on the driving machine.

31.1.9.2.10.4 Speed governor

Escalators shall be equipped in such a way that they stop automatically before the speed exceeds 1.2 times the rated speed. Where speed control devices are used for this purpose they shall have switched off the escalator before the speed exceeds 1.2 times the rated speed. It is permissible to disregard this requirement in case of a.c motors with a non-friction connection with the drive for the steps and whose slip does
not exceed 10 percent if thereby overspeed is prevented.

31.1.9.2.10.5 For operation and safety devices, electrical work, precautions and tests, reference maybe made to good pract
PART 32: SPECIAL CONSTRUCTION

User notes:
About this part: Part 31 provides regulations for unique buildings and building elements. Those include buildings such as membrane structures, greenhouses and relocatable buildings. Special elements include pedestrian walkways and tunnels, awnings, canopies and marquees, vehicular gates and solar energy systems.

32.1 GENERAL
32.1.1 Scope.
The provisions of this part shall govern special building construction including membrane structures, temporary structures, pedestrian walkways and tunnels, automatic vehicular gates, awnings and canopies, marquees, signs, towers, antennas, relocatable buildings, swimming pool enclosures and safety devices, and solar energy systems.

32.2 MEMBRANE STRUCTURES
32.2.1 General.
The provisions of Clauses 32.2.1 through 32.2.8 shall apply to air-supported, air-inflated, membrane-covered cable, membrane-covered frame and tensile membrane structures, collectively known as membrane structures, erected for a period of 180 days or longer. Those erected for a shorter period of time shall comply with the Ghana Fire Code. Membrane structures covering water storage facilities, water clarifiers, water treatment plants, sewage treatment plants, greenhouses and similar facilities not used for human occupancy are required to meet only the requirements of Clauses 32.2.3.1 and 32.2.7. Membrane structures erected on a building, balcony, deck or other structure for any period of time shall comply with this clause.

32.2.2 Tensile membrane structures and air-supported structures.
Tensile membrane structures and air-supported structures, including permanent and temporary structures, shall be designed and constructed in accordance with ASCE 55. The provisions in Clauses 32.2.3 through 32.2.6 shall apply.

32.2.3 Type of construction.
Noncombustible membrane structures shall be classified as Type I construction. Noncombustible frame or cable-supported structures covered by an approved membrane in accordance with Clause 32.2.3.1 shall be classified as Type I construction. Heavy timber frame-supported structures covered by an approved membrane in accordance with Clause 32.2.3.1 shall be classified as Type III construction. Other membrane structures shall be classified as Type IV construction.

Exception: Plastic less than 9144 mm (30 feet) above any floor used in greenhouses, where occupancy by the general public is not authorized, and for aquaculture pond covers is not required to meet the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of BS 476-6 and BS 476-7.

32.2.3.1 Membrane and interior liner material.
Membranes and interior liners shall be either noncombustible as set forth in this Code or meet the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, BS 476-6 and BS 476-7 of and the manufacturer's test protocol.

Exception: Plastic less than 0.5 mm (20 mil) in thickness used in greenhouses, where occupancy by the general public is not authorized, and for aquaculture pond covers is not required to meet the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of BS 476-6 and BS 476-7.

32.2.4 Allowable floor areas.
The area of a membrane structure shall not exceed the limitations specified in Clause 6.6.

32.2.5 Maximum height.
Membrane structures shall not exceed one storey nor shall such structures exceed the height limitations in feet specified in Clause 6.4.3.

Exception: Noncombustible membrane structures serving as roofs only.

32.2.6 Mixed construction.
Membrane structures shall be permitted to be utilized as specified in this clause as a portion of buildings of other types of construction. Height and area limits shall be as specified for the type of construction and occupancy of the building.

32.2.6.1 Noncombustible membrane.
A noncombustible membrane shall be permitted for use as the roof or as a skylight of any building or atrium of a building of any type of construction provided that the membrane is...
32.2.6.1.1 Membrane.
A membrane meeting the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of ASTM E84 shall be permitted to be used as the roof or as a skylight on buildings of Type I, II and III construction, provided that the membrane is not less than 6096 mm (20 feet) above any floor, balcony or gallery.

32.2.7 Engineering design.
The structure shall be designed and constructed to sustain dead loads; loads due to tension or inflation; live loads including wind, flood and seismic loads and in accordance with Part 17 structural Loads and designs.

32.2.7.1 Lateral restraint.
For membrane-covered frame structures, the membrane shall not be considered to provide lateral restraint in the calculation of the capacities of the frame members.

32.2.8 Inflation systems.
Air-supported and air-inflated structures shall be provided with primary and auxiliary inflation systems to meet the minimum requirements of Clauses 32.2.8.1 through 32.2.8.3.

32.2.8.1 Equipment requirements.
The inflation system shall consist of one or more blowers and shall include provisions for automatic control to maintain the required inflation pressures. The system shall be so designed as to prevent overpressurization of the system.

32.2.8.1.1 Auxiliary inflation system.
In addition to the primary inflation system, in buildings larger than 140 m² (1,500 square feet) in area, an auxiliary inflation system shall be provided with sufficient capacity to maintain the inflation of the structure in case of primary system failure. The auxiliary inflation system shall operate automatically when there is a loss of internal pressure and when the primary blower system becomes inoperative.

32.2.8.1.2 Blower equipment.
Blower equipment shall meet all of the following requirements:

1. Blowers shall be powered by continuous-rated motors at the maximum power required for any flow condition as required by the structural design.
2. Blowers shall be provided with inlet screens, belt guards and other protective devices as required by the building official to provide protection from injury.
3. Blowers shall be housed within a weather-protecting structure.
4. Blowers shall be equipped with backdraft check dampers to minimize air loss when inoperative.
5. Blower inlets shall be located to provide protection from air contamination. The location of inlets shall be approved.

32.2.8.2 Standby power.
Wherever an auxiliary inflation system is required, an approved standby power-generating system shall be provided. The system shall be equipped with a suitable means for automatically starting the generator set upon failure of the normal electrical service and for automatic transfer and operation of all of the required electrical functions at full power within 60 seconds of such service failure. Standby power shall be capable of operating independently for not less than 4 hours.

32.2.8.3 Support provisions.
A system capable of supporting the membrane in the event of deflation shall be provided for in air-supported and air-inflated structures having an occupant load of 50 or more or where covering a swimming pool regardless of occupant load. The support system shall be capable of maintaining membrane structures used as a roof for Type I structure not less than 6096 mm (20 feet) above floor or seating areas. The support system shall be capable of maintaining other membranes not less than 2134 mm (7 feet) above the floor, seating area or surface of the water.

32.3 TEMPORARY STRUCTURES
32.3.1 General.
The provisions of Clauses 32.3.1 through 32.3.4 shall apply to structures erected for a period of less than 180 days. Tents, umbrella structures and other membrane structures erected for a period of less than 180 days shall
comply with the Ghana Fire Code. Those erected for a longer period of time shall comply with applicable clauses of this Code.

32.3.1.1 Conformance.
Temporary structures and uses shall conform to the structural strength, fire safety, means of escape, accessibility, light, ventilation and sanitary requirements of this Code as necessary to ensure public health, safety and general welfare.

32.3.1.2 Permit required.
Temporary structures that cover an area greater than 11.16 m² (120 square feet), including connecting areas or spaces with a common means of escape or entrance that are used or intended to be used for the gathering together of 10 or more persons, shall not be erected, operated or maintained for any purpose without obtaining a permit from the building official.

32.3.2 Construction documents.
A permit application and construction documents shall be submitted for each installation of a temporary structure. The construction documents shall include a site plan indicating the location of the temporary structure and information delineating the means of escape and the occupant load.

32.3.3 Location.
Temporary structures shall be located in accordance with the requirements of Table 602 based on the fire-resistance rating of the exterior walls for the proposed type of construction.

32.3.4 Means of escape.
Temporary structures shall conform to the means of escape requirements of Part 11 and shall have an exit access travel distance of 30.480 mm (100 feet) or less.

32.4 PEDESTRIAN WALKWAYS AND TUNNELS
32.4.1 General.
This clause shall apply to connections between buildings such as pedestrian walkways or tunnels, located at, above or below grade level, that are used as a means of travel by persons. The pedestrian walkway shall not contribute to the building area or the number of stories or height of connected buildings.

32.4.1.1 Application.
Pedestrian walkways shall be designed and constructed in accordance with Clauses 32.4.2 through 32.4.9. Tunnels shall be designed and constructed in accordance with Clauses 32.4.2 and 32.4.10.

32.4.2 Separate structures.
Buildings connected by pedestrian walkways or tunnels shall be considered to be separate structures.

Exceptions:
1. Buildings that are on the same plot and considered as portions of a single building in accordance with Clause 6.3.1.2.
2. For purposes of calculating the number of Type B units required by Part 12, structurally connected buildings and buildings with multiple wings shall be considered to be one structure.

32.4.3 Construction.
The pedestrian walkway shall be of noncombustible construction.

Exceptions:
1. Combustible construction shall be permitted where connected buildings are of combustible construction.
2. Fire-retardant-treated wood, in accordance with Clause 7.3.1, Item 1.3, shall be permitted for the roof construction of the pedestrian walkway where connected buildings are not less than Type I construction.

32.4.4 Contents.
Only materials and decorations approved by the building official shall be located in the pedestrian walkway.

32.4.5 Connections of pedestrian walkways to buildings.
The connection of a pedestrian walkway to a building shall comply with Clause 32.4.5.1, 32.4.5.2, 32.4.5.3 or 32.4.5.4.
Exception: Buildings that are on the same plot and considered as portions of a single building in accordance with Clause 6.3.1.2.

32.4.5.1 Fire barriers.
Pedestrian walkways shall be separated from the interior of the building by not less than 2-hour fire barriers constructed in accordance with Clause 8.7 and Clauses 32.4.5.1.1 through 32.4.5.1.3.

32.4.5.1.1 Exterior walls.
Exterior walls of buildings connected to pedestrian walkways shall be 2-hour fire-resistance rated. This protection shall extend not less than 3048 mm (10 feet) in every direction surrounding the perimeter of the pedestrian walkway.

32.4.5.1.2 Openings in exterior walls of connected buildings.
Openings in exterior walls required to be fire-resistance rated in accordance with Clause 32.4.5.1.1 shall be equipped with opening protectives providing a not less than 3/4-hour fire protection rating in accordance with Clause 8.16.

32.4.5.1.3 Supporting construction.
The fire barrier shall be supported by construction as required by Clause 8.7.5.1.

32.4.5.2 Alternative separation.
The wall separating the pedestrian walkway and the building shall comply with Clause 32.4.5.2.1 or 32.4.5.2.2 where:

1. The distance between the connected buildings is more than 3048 mm (10 feet).

2. The pedestrian walkway and connected buildings are equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, and the roof of the walkway is not more than 16 764 mm (55 feet) above grade connecting to the fifth, or lower, storey above grade plane, of each building.

Exception: Open parking garages need not be equipped with an automatic sprinkler system.

32.4.5.2.1 Passage of smoke.
The wall shall be capable of resisting the passage of smoke.

32.4.5.2.2 Glass.
The wall shall be constructed of a tempered, wired or laminated glass and doors separating the interior of the building from the pedestrian walkway. The glass shall be protected by an automatic sprinkler system in accordance with Clause 10.3.3.1.1 that, when actuated, shall completely wet the entire surface of interior sides of the wall or glass. Obstructions shall not be installed between the sprinkler heads and the wall or glass. The glass shall be in a gasketed frame and installed in such a manner that the framing system will deflect without breaking (loading) the glass before the sprinkler operates.

32.4.5.3 Open sides on walkway.
Where the distance between the connected buildings is more than 3048 mm (10 feet), the walls at the interclause of the pedestrian walkway and each building need not be fire-resistance rated provided that both sidewalls of the pedestrian walkway are not less than 50 percent open with the open area uniformly distributed to prevent the accumulation of smoke and toxic gases. The roof of the walkway shall be located not more than 12 160 mm (40 feet) above grade plane, and the walkway shall only be permitted to connect to the third or lower storey of each building.

Exception: Where the pedestrian walkway is protected with a sprinkler system in accordance with Clause 10.3.3.1.1, the roof of the walkway shall be located not more than 16 764 mm (55 feet) above grade plane and the walkway shall only be permitted to connect to the fifth or lower storey of each building.

32.4.5.4 Exterior walls with fire rating greater than 2 hours
Where exterior walls of connected buildings are required by Clause 8.5 to have a fire-resistance rating greater than 2 hours, the walls at the interclause of the pedestrian walkway and each building need not be fire-resistance rated provided:

1. The pedestrian walkway is equipped throughout with an automatic sprinkler system installed in accordance with Clause 10.3.3.1.1.

2. The roof of the walkway is not located more than 16 764 mm (55 feet) above grade plane and the walkway connects to the fifth, or lower, storey above grade plane of each building.
32.4.6 Public way.
Pedestrian walkways over a public way shall comply with Part 33.

32.4.7 Escape.
Access shall be provided at all times to a pedestrian walkway that serves as a required exit.

32.4.8 Width.
The unobstructed width of pedestrian walkways shall be not less than 914 mm (36 inches). The total width shall be not greater than 9144 mm (30 feet).

32.4.9 Exit access travel.
The length of exit access travel shall be 60 960 mm (200 feet) or less.
Exceptions:
1. Exit access travel distance on a pedestrian walkway equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1 shall be 76 200 mm (250 feet) or less.
2. Exit access travel distance on a pedestrian walkway constructed with both sides not less than 50 percent open shall be 91 440 mm (300 feet) or less.
3. Exit access travel distance on a pedestrian walkway constructed with both sides not less than 50 percent open, and equipped throughout with an automatic sprinkler system in accordance with Clause 10.3.3.1.1, shall be 122 m (400 feet) or less.

32.4.10 Tunneled walkway.
Separation between the tunneled walkway and the building to which it is connected shall be not less than 2-hour fire-resistant construction and openings therein shall be protected in accordance with Clause 8.16.

32.5 AWNINGS AND CANOPIES

32.5.1 General.
Awnings and canopies shall comply with the requirements of Clauses 32.5.2 and 32.5.3 and other applicable clauses of this Code.

32.5.2 Design and construction.
Awnings and canopies shall be designed and constructed to withstand wind or other lateral loads and live loads as required by Part 17 (structural loads and designs) with due allowance for shape, open construction and similar features that relieve the pressures or loads. Structural members shall be protected to prevent deterioration. Awnings shall have frames of noncombustible material, fire-retardant-treated wood, heavy timber complying with Clause 24.4.11, or 1-hour construction with combustible or noncombustible covers and shall be either fixed, retractable, folding or collapsible.

32.5.3 Awnings and canopy materials.
Awnings and canopies shall be provided with an approved covering that complies with one of the following:
1. The fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of ASTM E 84.
2. Has a flame spread index not greater than 25 when tested in accordance with ASTM E84
3. Meets all of the following criteria when tested in accordance with ASTM E 119:
   3.1. During the 40 kW exposure, flames shall not spread to the ceiling.
   3.2. Flashover, as defined in ASTM E 119, shall not occur.
   3.3. The flame shall not spread to the outer extremity of the sample on any wall or ceiling.
   3.4. The peak heat release rate throughout the test shall not exceed 800 kW.

Exception: The fire propagation performance and flame spread index requirements shall not apply to awnings installed on detached one- and two-family dwellings.

32.6 MARQUEES

32.6.1 General.
Marquees shall comply with Clauses 32.6.2 through 32.6.5 and other applicable clauses of this Code.
32.6.2 Thickness.
The height or thickness of a marquee measured vertically from its lowest to its highest point shall be not greater than 914 mm (3 feet) where the marquee projects more than two-thirds of the distance from the property line to the curb line, and shall be not greater than 2743 mm (9 feet) where the marquee is less than two-thirds of the distance from the property line to the curb line.

32.6.3 Roof construction.
Where the roof or any part thereof is a skylight, the skylight shall comply with the requirements of Part 25. Every roof and skylight of a marquee shall be sloped to downspouts that shall conduct any drainage from the marquee in such a manner so as not to spill over the sidewalk.

32.6.4 Location prohibited.
Every marquee shall be so located as not to interfere with the operation of any exterior standpipe, and such that the marquee does not obstruct the clear passage of stairways or exit discharge from the building or the installation or maintenance of street lighting.

32.6.5 Construction.
A marquee shall be supported entirely from the building and constructed of noncombustible materials. Marquees shall be designed as required in Part 17 (structural load and design). Structural members shall be protected to prevent deterioration.

32.7 SIGNS
32.7.1 General.
Signs shall be designed, constructed and maintained in accordance with this Code.

32.8 TELECOMMUNICATION AND BROADCAST TOWERS
32.8.1 General.
Towers shall be designed and constructed in accordance with the provisions of this Code. Towers shall be designed for seismic loads; exceptions related to seismic design listed in this Code shall not apply. The horizontal extent of Topographic Category 2, escarpments, shall be 16 times the height of the escarpment.

Exception: Single free-standing poles used to support antennas not greater than 22 860 mm (75 feet), measured from the top of the pole to grade, shall not be required to be noncombustible.

32.8.2 Location and access.
Towers shall be located such that guy wires and other accessories shall not cross or encroach on any street or other public space, or over above-ground electric utility lines, or encroach on any privately owned property without the written consent of the owner of the encroached-upon property, space or above-ground electric utility lines. Towers shall be equipped with climbing and working facilities in compliance with this Code. Access to the tower sites shall be limited as required by this Code.

32.9 SWIMMING POOLS, SPAS AND HOT TUBS
32.9.1 General.
The design and construction of swimming pools, spas and hot tubs shall comply with this Code.

32.10 AUTOMATIC VEHICULAR GATES
32.10.1 General.
Automatic vehicular gates shall comply with the requirements of Clauses 32.10.2 and 32.10.3 and other applicable clauses of this Code.

32.10.2 Vehicular gates intended for automation.
Vehicular gates intended for automation shall be designed, constructed and installed to comply with the requirements of ASTM F 2200.

32.10.3 Vehicular gate openers.
Vehicular gate openers, where provided, shall be listed in accordance with this Code.

32.11 SOLAR ENERGY SYSTEMS
32.11.1 General.
Solar energy systems shall comply with the requirements of this clause.

32.11.1.1 Wind resistance.
Rooftop-mounted photovoltaic panels and modules and solar thermal collectors shall be designed in accordance with Clause 17.9.

32.11.1.2 Roof live load.
Roof structures that provide support for solar energy systems shall be designed in accordance with Clause 17.7.13.5.
32.11.2 Solar thermal systems.
Solar thermal systems shall be designed and installed in accordance with Clause 27.6.12, the Ghana Fire Code.

32.11.2.1 Equipment.
Solar thermal systems and components shall be listed and labeled in accordance with this Code.

32.11.3 Photovoltaic solar energy systems.
Photovoltaic solar energy systems shall be designed and installed in accordance with this clause, the Ghana Fire Code.

32.11.3.1 Equipment.
Photovoltaic panels and modules shall be listed and labeled in accordance with this Code. Inverters shall be listed and labeled in accordance with this Code. Systems connected to the utility grid shall use inverters listed for utility interaction.

32.11.3.2 Fire classification.
Rooftop-mounted photovoltaic systems shall have a fire classification in accordance with Clause 16.5.9. Building-integrated photovoltaic systems shall have a fire classification in accordance with Clause 16.5.8.

32.11.3.3 Building-integrated photovoltaic systems.
Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Clause 16.7.18.

32.11.3.4 Access and pathways.
Roof access, pathways and spacing requirements shall be provided in accordance with the Ghana Fire Code.

32.11.3.5 Ground-mounted photovoltaic systems.
Ground-mounted photovoltaic systems shall be designed and installed in accordance with Part 16 and the Ghana Fire Code.

32.11.3.5.1 Fire separation distances.
Ground-mounted photovoltaic systems shall be subject to the fire separation distance requirements determined by National jurisdiction.

32.12 GREENHOUSES
32.12.1 General.
The provisions of this clause shall apply to greenhouses that are designed and used for the cultivation, maintenance, or protection of plants.

32.12.2 Accessibility.
Greenhouses shall be accessible in accordance with Part 12.

32.12.3 Structural design.
Greenhouses shall comply with the structural design requirements for greenhouses in Part 17.

32.12.4 Glass and glazing.
Glass and glazing used in greenhouses shall comply with Clause 25.5.

32.12.5 Light-transmitting plastics.
Light-transmitting plastics shall be permitted in lieu of plain glass in greenhouses and shall comply with Clause 27.6.

32.12.6 Membrane structures.
Greenhouses that are membrane structures shall comply with Clause 32.2.

32.12.6.1 Plastic film.
Plastic films used in greenhouses shall comply with Clause 32.2.3.

32.13 RELOCATABLE BUILDINGS
32.13.1 General.
The provisions of this clause shall apply to relocatable buildings. Relocatable buildings manufactured after the effective date of this Code shall comply with the applicable provisions of this Code.

Exception: This clause shall not apply to manufactured housing used as dwellings.

32.13.1.1 Compliance.
A newly constructed relocatable building shall comply with the requirements of this Code for new construction. An existing relocatable building that is undergoing alteration, addition, change of occupancy or relocation shall comply with this Code.

32.13.2 Supplemental information.
Supplemental information specific to a relocatable building shall be submitted to the MMDAs. It shall, as a minimum, include the
following in addition to the information required by part 1:

1. Manufacturer’s name and address.
2. Date of manufacture.
3. Serial number of module.
4. Manufacturer’s design drawings.
5. Type of construction in accordance with Clause 7.2.
6. Design loads including: roof live load, floor live load, wind load and seismic site class, use group and design category.
7. Additional building planning and structural design data.
8. Site-built structure or appurtenance attached to the relocatable building.

32.13.3 Manufacturer’s data plate.

Each relocatable module shall have a data plate that is permanently attached on or adjacent to the electrical panel, and shall include the following information:

1. Occupancy group.
2. Manufacturer’s name and address.
3. Date of manufacture.
4. Serial number of module.
5. Design roof live load, design floor live load, wind and seismic design.
6. Approved quality assurance agency or approved inspection agency.
7. Codes and standards of construction.
8. Envelope thermal resistance values.
9. Electrical service size.
10. Fuel-burning equipment and size.
11. Special limitations if any.


For one-storey buildings, foam plastic having a flame spread index of 25 or less, and a smoke-developed index of not more than 450, shall be permitted without thermal barriers in or on exterior walls in a thickness not more than 102 mm (4 inches) where the foam plastic is covered by a thickness of not less than 0.81 mm (0.032-inch-thick) aluminum or corrosion-resistant steel having a base metal thickness of 0.41 mm (0.0160 inch) and the building is equipped throughout with an automatic sprinkler system in accordance with Code.

32.14.2 Roofing.

A thermal barrier is not required for foam plastic insulation that is a part of a Class A, B or C roof-covering assembly that is installed in accordance with the Code and the manufacturer’s instructions and is either constructed as described in Item 1 or tested as described in Item 2.

1. The roof assembly is separated from the interior of the building by wood structural panel sheathing not less than 11.9 mm (0.47 inch) in thickness bonded with exterior glue, with edges supported by blocking, tongue-and-groove joints, other approved type of edge support or an equivalent material.

2. The assembly with the foam plastic insulation satisfactorily passes with this Code.

32.14.3 Attics and crawl spaces.

Within an attic or crawl space where entry is made only for service of utilities, foam plastic insulation shall be protected against ignition by 38mm (1\(\frac{1}{2}\)-inch-thick) mineral fiber insulation; 6.4 mm (1\(\frac{1}{4}\)-inch-thick) wood structural panel, particleboard or hardboard; 9.5 mm (3\(\frac{1}{8}\)-inch) gypsum wallboard, corrosion-resistant steel having a base metal thickness 0.4 mm (of 0.016 inch); 38 mm (1\(\frac{1}{2}\)-inch-thick) self-supported spray-applied
cellulose insulation in attic spaces only or other approved material installed in such a manner that the foam plastic insulation is not exposed. The protective covering shall be consistent with the requirements for the type of construction.

32.14.3 Doors not required to have a fire protection rating.
Where pivoted or side-hinged doors are permitted without a fire protection rating, foam plastic insulation, having a flame spread index of 75 or less and a smoke-developed index of not more than 450, shall be permitted as a core material where the door facing is of metal having a minimum thickness of 0.8 mm (0.032-inch) aluminum or steel having a base metal thickness of not less than 0.4 mm (0.016 inch) at any point.

In occupancies classified as Group R-2 or R-3, foam-filled exterior entrance doors to individual dwelling units that do not require a fire-resistance rating shall be faced with aluminum, steel, fiberglass, wood or other approved materials.

32.14.4 Garage doors.
Where garage doors are permitted without a fire-resistance rating and foam plastic is used as a core material, the door facing shall be metal having a minimum thickness of 0.8 mm (0.032-inch) aluminum or 0.25 mm (0.010-inch) steel or the facing shall be minimum 3.2 mm (0.125-inch-thick) wood.

Exception: Garage doors using foam plastic insulation complying with this Code in detached and attached garages associated with one- and two-family dwellings need not be provided with a thermal barrier.

32.14.5 Siding backer board.
Foam plastic insulation of not more than 2,000 British thermal units per square feet (Btu/sq. ft.) (22.7 mJ/m²) as determined by NFPA 259 shall be permitted as a siding backer board with a maximum thickness of 12.7 mm (1/2 inch), provided that it is separated from the interior of the building by not less than 51 mm (2 inches) of mineral fiber insulation or equivalent or where applied as insulation with re-siding over existing wall construction.
33.1 GENERAL
33.1.1 Scope.
The provisions of this part shall govern the encroachment of structures into the public right-of-way.

General Rule
(1) No part of a building, including any portico, verandah or other projections (except for the eaves), shall be constructed as to extend beyond the building line of any street upon which the building may front, abut or adjoin unless otherwise authorized by the District Planning Authority.

(2) The eaves of any building which abuts upon any street shall not project into the street more than 600mm beyond the face of the wall of the building and shall be at a height level of not less than 3 metres above ground.

(3) Entrance gates, doors, windows and shutters shall be so hung that they open entirely on to the owner's property and in no case shall they be hung to open beyond a building line or fence line, if the building line or fence line abuts upon any street or any public road, lane or foot path.

(4) No building shall be constructed such that any part of it cuts and projects above an imaginary line from the building line on the opposite side of the street at ground level so as to produce an angle of 45 degrees to the horizontal, except in accordance with permission granted by the District Planning Authority.

(5) No building shall be allowed to intrude into areas reserved for improvement lines.

33.2 ENCROACHMENTS
33.2.1 Measurement.
The projection of any structure or portion thereof shall be the distance measured horizontally from the plinth line to the outermost point of the projection.

33.2.3 Other IEN 310.
The provisions of this clause shall not be construed to permit the violation of other IEN 310 or ordinances regulating the use and occupancy of public property.

33.2.4 Drainage.
Drainage water collected from a roof, awning, canopy or marquee, and condensate from mechanical equipment shall not flow over a public walking surface.

33.2.5 Encroachments below grade.
Encroachments below grade shall comply with Clauses 33.2.5.1 through 33.2.5.3.

33.2.5.1 Structural support.
A part of a building erected below grade that is necessary for structural support of the building or structure shall not project beyond the plinth lines, except that the footings of street walls or their supports that are located not less than 2438 mm (8 feet) below grade shall not project more than 305 mm (12 inches) beyond the street plinth line.

33.2.5.2 Vaults and other enclosed spaces.
The construction and utilization of vaults and other enclosed spaces below grade shall be subject to the terms and conditions of the applicable governing authority.

33.2.5.3 Areaways.
Areaways shall be protected by grates, guards or other approved means.

33.2.6 Encroachments above grade and below 8 feet in height.
Encroachments into the public right-of-way above grade and below 2438 mm (8 feet) in height shall be prohibited except as provided for in Clauses 33.2.2.1 through 33.2.6.3. Doors and windows shall not open or project into the public right-of-way.

33.2.6.1 Steps.
Steps shall not project more than 305 mm (12 inches) and shall be guarded by approved devices not less than 914 mm (3 feet) in height or shall be located between columns or pilasters.

33.2.6.2 Architectural features.
Columns or pilasters, including bases and moldings, shall not project more than 305 mm (12 inches). Belt courses, lintels, sills, architraves, pediments and similar architectural features shall not project more than 102 mm (4 inches).

33.2.6.3 Awnings.
The vertical clearance from the public right-of-way to the lowest part of any awning, including valances, shall be not less than 2134 mm (7 feet).
33.2.7 Encroachments 8 feet or more above grade.

Encroachments 2438 mm (8 feet) or more above grade shall comply with Clauses 33.2.7.1 through 33.2.7.4.

33.2.7.1 Awnings, canopies, marquees and signs.

Awnings, canopies, marquees and signs shall be constructed so as to support applicable loads as specified in Part 16. Awnings, canopies, marquees and signs with less than 4572 mm (15 feet) of clearance above the sidewalk shall not extend into or occupy more than two-thirds the width of the sidewalk measured from the building. Stanchions or columns that support awnings, canopies, marquees and signs shall be located not less than 610 mm (2 feet) in from the curb line.

33.2.7.2 Windows, balconies, architectural features and mechanical equipment.

Where the vertical clearance above grade to projecting windows, balconies, architectural features or mechanical equipment is more than 2438 mm (8 feet), 25 mm (1 inch) of encroachment is permitted for each additional 25 mm (1 inch) of clearance above 2438 mm (8 feet), but the maximum encroachment shall be 1219 mm (4 feet).

33.2.7.3 Pedestrian walkways.

The installation of a pedestrian walkway over a public right-of-way shall be subject to the approval of the applicable governing authority. The vertical clearance from the public right-of-way to the lowest part of a pedestrian walkway shall be not less than 4572 mm (15 feet).

PART 34: SAFEGUARDS DURING CONSTRUCTION
(HEALTH, SAFETY AND ENVIRONMENT)

User notes:
About this part: While the balance of the parts in this Code specify how a building is to be designed and constructed in order to be in compliance with the Code, Part 34 looks to the actual construction process. Parameters are provided for demolition and for protecting adjacent property during demolition and construction. Issues such as how to provide escape while the building is developing, the timing of stand-pipe and sprinkler installation, and protection of pedestrians are addressed.

34.1 GENERAL
34.1.1 Scope.

The provisions of this part shall govern safety during construction and the protection of adjacent public and private properties.

34.1.2 Storage and placement.

Construction equipment and materials shall
be stored and placed so as not to endanger the public, the workers or adjoining property for the duration of the construction project.

34.2 CONSTRUCTION SAFEGUARDS
34.2.1 Alterations, repairs and additions.

Required exits, existing structural elements, fire protection devices and sanitary safeguards shall be maintained at all times during alterations, repairs or additions to any building or structure.

Exceptions:
1. Where such required elements or devices are being altered or repaired, adequate substitute provisions shall be made.
2. Maintenance of such elements and devices is not required where the existing building is not occupied.

34.2.2 Manner of removal.

Waste materials shall be removed in a manner that prevents injury or damage to persons, adjoining properties and public rights-of-way. Fire safety during construction shall comply with the applicable requirements of this Code and the applicable provisions of the Ghana Fire Code.

34.3 DEMOLITION
34.3.1 Construction documents.

Construction documents and a schedule for demolition shall be submitted where required by the Head of works department. Where such information is required, work shall not be done until such construction documents or schedule, or both, are approved.

34.3.2 Pedestrian protection.

The work of demolishing any building shall not be commenced until pedestrian protection is in place as required by this part.

34.3.3 Means of Escape

A horizontal exit shall not be destroyed unless and until a substitute means of escape has been provided and approved.

34.3.4 Vacant pplot.

Where a structure has been demolished or removed, the vacant pplot shall be filled and maintained to the existing grade or in accordance with the ordinances of the jurisdiction having authority.

34.3.5 Water accumulation.

Provision shall be made to prevent the accumulation of water or damage to any foundations on the premises or the adjoining property.

34.3.6 Utility connections.

Service utility connections shall be discontinued and capped in accordance with the approved rules and the requirements of the applicable governing authority.

34.3.7 Fire safety during demolition.

Fire safety during demolition shall comply with the applicable requirements of this Code.

34.4 SITE WORK
34.4.1 Excavation and fill.

Excavation and fill for buildings and structures shall be constructed or protected so as not to endanger life or property. Stumps and roots shall be removed from the soil to a depth of not less than 305 mm (12 inches) below the surface of the ground in the area to be occupied by the building. Wood forms that have been used in placing concrete, if within the ground or between foundation sills and the ground, shall be removed before a building is occupied or used for any purpose. Before completion, loose or casual wood shall be removed from direct contact with the ground under the building.

34.4.1.1 Slope limits.

Slopes for permanent fill shall be not steeper than one unit vertical in two units horizontal (50-percent slope). Cut slopes for permanent excavations shall be not steeper than one unit vertical in two units horizontal (50-percent slope). Deviation from the foregoing limitations for cut slopes shall be permitted only upon the presentation of a soil investigation report acceptable to the Head of works department.

34.4.1.2 Surcharge.

Fill or other surcharge loads shall not be placed adjacent to any building or structure unless such building or structure is capable of withstanding the additional loads caused by the fill or surcharge. Existing footings or foundations that can be affected by any excavation shall be underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
34.4.1.3 Footings on adjacent slopes.
For footings on adjacent slopes, see Part 18.

34.4.1.4 Fill supporting foundations.
Fill to be used to support the foundations of any building or structure shall comply with Clause 18.4.6. Special inspections of compacted fill shall be in accordance with Clause 19.5.6.

34.5 SANITARY
34.5.1 Facilities required.
Sanitary facilities shall be provided during construction, remodeling or demolition activities in accordance with this Code.

34.6 PROTECTION OF PEDESTRIANS
34.6.1 Protection required.
Pedestrians shall be protected during construction, remodeling and demolition activities as required by this part and Table 34.6.1. Signs shall be provided to direct pedestrian traffic.

<table>
<thead>
<tr>
<th>TABLE 34.6.1 PROTECTION OF PEDESTRIANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEIGHT OF CONSTRUCTION</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>8 feet or less</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>More than 8 feet</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note: For SI: 1 foot = 304.8 mm.

34.6.2 Walkways.
A walkway shall be provided for pedestrian travel in front of every construction and demolition site unless the applicable governing authority authorizes the sidewalk to be fenced or closed. A walkway shall be provided for pedestrian travel that leads from a building entrance or exit of an occupied structure to a public way. Walkways shall be of sufficient width to accommodate the pedestrian traffic, but shall be not less than 1219 mm (4 feet) in width. Walkways shall be provided with a durable walking surface. Walkways shall be accessible in accordance with Part 12 and shall be designed to support all imposed loads, and the design live load shall be not less than 150 pounds per square foot (psf) (7.2 kN/m²).

34.6.3 Directional barricades.
Pedestrian traffic shall be protected by a directional barricade where the walkway extends into the street. The directional barricade shall be of sufficient size and construction to direct vehicular traffic away from the pedestrian path.

34.6.4 Construction railings.
Construction railings shall be not less than 1067 mm (42 inches) in height and shall be sufficient to direct pedestrians around construction areas.

34.6.5 Barriers.
Barriers shall be not less than 2438 mm (8 feet) in height and shall be placed on the side of the walkway nearest the construction. Barriers shall extend the entire length of the construction site. Openings in such barriers shall be protected by doors that are normally kept closed.

34.6.6 Barrier design.
Barriers shall be designed to resist loads required in Part 17 unless constructed as follows:

1. Barriers shall be provided with 51 mm by 102 mm (2-inch by 4-inch) top and bottom plates.
2. The barrier material shall be boards not less than 19.1 mm (3/4 inch) thick or wood structural panels not less than 6.4 mm (1/4 inch) thick.
3. Wood structural use panels shall be bonded with an adhesive identical to that for exterior wood structural use panels.
4. Wood structural use panels 6.4 mm (1/4 inch) or 23.8 mm (5/16 inch) in thickness shall have studs spaced not more than 610 mm (2 feet) on center.
(3/8 inch) or 12.7 mm (1/2 inch) in thickness shall have studs spaced not more than 1219 mm (4 feet) on center provided that a 51 mm by 102 mm (2-inch by 4-inch) stiffener is placed horizontally at mid-height where the stud spacing is greater than 610 mm (2 feet) on center.

6. Wood structural use panels 15.9 mm (5/8 inch) or thicker shall not span over 2438 mm (8 feet).

34.6.7 Covered walkways.

Covered walkways shall have a clear height of not less than 2438 mm (8 feet) as measured from the floor surface to the canopy overhead. Adequate lighting shall be provided at all times. Covered walkways shall be designed to support all imposed loads. The design live load shall be not less than 150 psf (7.2 kN/m²) for the entire structure.

Exception:

Roofs and supporting structures of covered walkways for new, light-frame construction not exceeding two stories above grade plane are permitted to be designed for a live load of 75 psf (3.6kN/m²) or the loads imposed on them, whichever is greater. In lieu of such designs, the roof and supporting structure of a covered walkway are permitted to be constructed as follows:

1. Footings shall be continuous 51 mm by 152 mm (2-inch by 6-inch) members.
2. Posts not less than 102 mm by 152 mm (4 inches by 6 inches) shall be provided on both sides of the roof and spaced not more than 3658 mm (12 feet) on center.
3. Stringers not less than 102 mm by 305 mm (4 inches by 12 inches) shall be placed on edge upon the posts.
4. Joists resting on the stringers shall be not less than 51 mm by 203 mm (2 inches by 8 inches) and shall be spaced not more than 610 mm (2 feet) on center.
5. The deck shall be planks not less than 51 mm (2 inches) thick or wood structural panels with an exterior exposure durability classification not less than 18.3 mm (3/4 inch) thick nailed to the joists.
6. Each post shall be knee braced to joists and stringers by members not less than 51 mm by 102 mm (2 inches by 4 inches); 1219 mm (4 feet) in length.
7. A curb that is not less than 51 mm by 102 mm (2 inches by 4 inches) shall be set on edge along the outside edge of the deck.

34.6.8 Repair, maintenance and removal.

Pedestrian protection required by this part shall be maintained in place and kept in good order for the entire length of time pedestrians are subject to being endangered. The owner or the owner's authorized agent, on completion of the construction activity, shall immediately remove walkways, debris and other obstructions and leave such public property in as good a condition as it was before such work was commenced.

34.6.9 Adjacent to excavations.

Every excavation on a site located 1524 mm (5 feet) or less from the street boundary line shall be enclosed with a barrier not less than 1829 mm (6 feet) in height. Where located more than 1524 mm (5 feet) from the street boundary line, a barrier shall be erected where required by the Head of works department. Barriers shall be of adequate strength to resist wind pressure as specified in Part 17 (Structural loads and design).

34.7 PROTECTION OF ADJOINING PROPERTY

33.7.1 Protection required.

Adjoining public and private property shall be protected from damage during construction, remodeling and demolition work. Protection shall be provided for footings, foundations, party walls, chimneys, skylights and roofs. Provisions shall be made to control water runoff and erosion during construction or demolition activities. The person making or causing an excavation to be made shall provide written notice to the owners of adjoining buildings advising them that the excavation is to be made and that the adjoining buildings should be protected. Said notification shall be delivered not less than 10 days prior to the scheduled starting date of the excavation.

34.8 TEMPORARY USE OF STREETS, ALLEYS AND PUBLIC PROPERTY

34.8.1 Storage and handling of materials.

The temporary use of streets or public property for the storage or handling of materials or of equipment required for construction or demolition, and the protection provided to the public shall comply with the
provisions of the applicable governing authority and this part.

34.8.1 Obstructions.

Construction materials and equipment shall not be placed or stored so as to obstruct access to fire hydrants, standpipes, fire or police alarm boxes, catch basins or manholes, nor shall such material or equipment be located within 6096 mm (20 feet) of a street inter- clause, or placed so as to obstruct normal observations of traffic signals or to hinder the use of public transit loading platforms.

34.8.2 Utility fixtures.

Building materials, fences, sheds or any obstruction of any kind shall not be placed so as to obstruct free approach to any fire hydrant, fire department connection, utility pole, manhole, fire alarm box or catch basin, or so as to interfere with the passage of water in the gutter. Protection against damage shall be provided to such utility fixtures during the progress of the work, but sight of them shall not be obstructed.

34.9 FIRE EXTINGUISHERS

34.9.1 Where required.

Structures under construction, alteration or demolition shall be provided with not fewer than one approved portable fire extinguisher in accordance with this Code and sized for not less than ordinary hazard as follows:
1. At each stairway on all floor levels where combustible materials have accumulated.
2. In every storage and construction shed.
3. Additional portable fire extinguishers shall be provided where special hazards exist, such as the storage and use of flammable and combustible liquids.

34.9.2 Fire hazards.

The provisions of this Code and the Ghana Fire Code shall be strictly observed to safeguard against all fire hazards attendant upon construction operations. All necessary measures shall be taken to protect electrical cables and other related services in order to prevent the hazard caused by electricity. Warning signs shall be displayed where necessary to indicate hazards, for example:

(a) ‘440 VOLTS’,
(b) ‘DO NOT SMOKE’,
(c) ‘MEN WORKING AHEAD’, etc.

34.10 MEANS OF ESCAPE

34.10.1 Stairways required.

Where building construction exceeds 12 192 mm (40 feet) in height above the lowest level of fire department vehicle access, a temporary or permanent stairway shall be provided. As construction progresses, such stairway shall be extended to within one floor of the highest point of construction having secured decking or flooring.

34.10.2 Maintenance of means of escape.

Means of escape and required accessible means of escape shall be main- tained at all times during construction, demolition, remodeling or alterations and additions to any building.

Exception: Existing means of escape need not be main- tained where approved temporary means of escape systems and facilities are provided.

34.11 STANDPIPES

34.11.1 Where required.

In buildings required to have standpipes by Clause 10.5.3.1, not fewer than one Fire hydrant shall be provided for use during construction. Such stand- pipes shall be installed prior to construction exceeding 12 192 mm (40 feet) in height above the lowest level of fire department vehicle access. Such standpipes shall be provided with fire department hose connections at locations adjacent to stairways complying with Clause 3310.1. As construction progresses, such standpipes shall be extended to within one floor of the highest point of construction having secured decking or flooring.

34.11.2 Buildings being demolished.

Where a building is being demolished and a Fire hydrant exists within such a build- ing, such Fire hydrant shall be maintained in an operable condi- tion so as to be available for use by the fire department. Such Fire hydrant shall be demolished with the building but shall not be demolished more than one floor below the floor being demolished.

34.11.3 Detailed requirements.

Standpipes shall be installed in accordance with the provisions of Part 10. Exception: Standpipes shall be either temporary or permanent in nature, and with or without a water supply, provided that such standpipes conform to the requirements of Clause 10.5 as to capacity, outlets and materials.
34.12 AUTOMATIC SPRINKLER SYSTEM

34.12.1 Completion before occupancy.
In buildings where an automatic sprinkler system is required by this Code, it shall be unlawful to occupy any portion of a building or structure until the automatic sprinkler system installation has been tested and approved, except as provided in Clause 10.3.

34.12.2 Operation of valves.
Operation of sprinkler control valves shall be permitted only by properly authorized personnel and shall be accompanied by notification of duly designated parties. When the sprinkler protection is being regularly turned off and on to facilitate connection of newly completed segments, the sprinkler control valves shall be checked at the end of each work period to ascertain that protection is in service.

34.13 WATER SUPPLY FOR FIRE PROTECTION
34.13.1 Where required.
An approved water supply for fire protection, either temporary or permanent, shall be made available as soon as combustible material arrives on the site.

34.14 FIRE WATCH DURING CONSTRUCTION
34.14.1 Fire watch during combustible construction.
Where required by the GNFS a fire watch shall be provided during nonworking hours for construction that exceeds 12 192 mm (40 feet) in height above the lowest adjacent grade.

34.15 GENERAL HEALTH SAFETY AND ENVIRONMENT
Reference shall be made to ISO 45001 in the development of occupational health safety and environmental management plan.
PART 35: SMALL BUILDINGS

35.1 GENERAL
35.1.1 Scope
This part applies to buildings of two (2) storeys or less in building height having a building area not exceeding 220 $m^2$ and which are used or intended to be used for residential (Group R), business and personal services (Group B), Mercantile (Group M) and medium and low hazard industrial occupancy (Group S). This part applies both to site assembled and factorymade buildings. Occupancy group classifications are as described in Clause 3.2 of Part 3 of this Code.

35.2 MATERIALS, SYSTEMS AND EQUIPMENT
35.2.1 General
This clause provides the requirements for materials, systems and equipment in small buildings.

35.2.1.1 Performance
Materials, systems and equipment shall possess the essential properties necessary to perform their intended functions.

35.2.1.2 Required Tests
When required by the authority having jurisdiction, materials, systems or equipment shall be tested to determine the suitability for their intended use.

35.2.1.3 Published Test Methods
Except as provided in Article 35.2.1.5, the test method used to determine the suitability of materials, systems or equipment shall be one that is published by a government recognized agency.

35.2.1.4 Assessment of Materials, Systems and Equipment
Materials, systems and equipment not specifically described herein, or which vary from specific requirements in this Part, or for which no recognized test procedure has been established, may be used if it can be shown that the material, system or equipment is suitable on the basis of past performance or good engineering practice or on the basis of tests described in Article 35.2.1.5.

35.2.1.5 Absence of Published Test Methods
Where no published test method exists, the tests shall be designed to simulate or exceed anticipated service conditions or shall be designed to compare the performance of the material, system or equipment with similar material, system or equipment that is known to be acceptable.

35.2.1.6 Testing Laboratories
Every test shall be carried out by a testing laboratory acceptable to the government recognized authority having jurisdiction.

35.2.1.7 Conflict with Reference Documents
When a specification or reference document listed herein contains requirements that conflict with specific requirements in this Part, the requirements in this Part shall govern.

35.2.1.8 Short-lived or Otherwise Unsuitable Materials
Where plans of a building show that it is proposed to use short-lived materials, the authority having jurisdiction may, notwithstanding that the plans conform with the regulations:

(1) (i) reject the plans; or (ii) in passing the plans, fix a period on the expiration of which the building must be removed and impose such reasonable conditions which, having regard to the nature of the materials are appropriate.

(2) the authority having jurisdiction may extend any period fixed if they find at the end of this period that the condition of the structure is still in a suitable condition.

35.2.2 Concrete
Refer to Part 20 (Concrete) of this code.
35.2.3 Timber and wood products
Refer to part 24 (Wood, bamboo and rattan) of this code.

35.2.4 Metal
Refer to Parts 21 and 23 of this code.

35.3 LOADS
35.3.1 General
35.3.1.1 When the size of structural members and their connections are not given in this Part, the members and their connections shall conform to Part 17 of this Code, except that design imposed (live) loads and deflection limits shall conform to subclauses 35.3.2 to 35.3.6.

35.3.2 Floor loads
The minimum design live loads on a floor area shall be taken as being equal to a uniformly applied load over the entire area or a concentrated load whichever produces greater and shall be based on the intended use and occupancy as set out in Table 35.3.2.A

Table 35.3.2.A – Minimum design imposed (live) floor loads
(Forming Part of Article 35.3.2)

<table>
<thead>
<tr>
<th>Use of Area of Floor</th>
<th>Minimum design live load (kN/m²)</th>
<th>Minimum concentrated design load over any square with a 300mm side (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corridors, lobbies and aisles over 1.2m width, except for public corridors above first storey in residential occupancies</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>-</td>
</tr>
<tr>
<td>Corridors, lobbies and aisles not over 1.2m in width</td>
<td>2.0(2)</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>-</td>
</tr>
<tr>
<td>Balconies</td>
<td>2.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Equipment rooms</td>
<td>To be determined but not less</td>
<td>To be determined but not less than</td>
</tr>
<tr>
<td>Exits</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Factories, Light</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Medium</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Heavy</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Garages For passenger cars unloaded buses and light trucks not exceeding 2500 kg including driveways and ramps</td>
<td>0.4</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>-</td>
</tr>
<tr>
<td>All repair workshops for all types of vehicles and parking for vehicles exceeding 2500 kg gross weight including driveways and ramps</td>
<td>3.6</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Kitchens
other than domestic

Office areas
basement and first storeys

Laboratories

Residential occupancies

attics not accessible by a stairway

attics accessible by a stairway

bedrooms

all other rooms

stairs within dwelling units

Mercantile occupancies

Notes on Table 35.3.2.A
(1) Corridors, lobbies and aisles over 1.2m width shall be designed to carry not less than the design load required for the occupancies they serve.

(2) Total equipment loads must be calculated and allowed for in the design.

### 35.3.3 Roof live loads other than wind loads or rain loads

35.3.3.1 Roof (whether flat or pitched) of a house having not more than three storeys and intended for occupation by one family only to which there is only such access as may be necessary for the purposes of maintenance or repair shall withstand an imposed load of 720N/m\(^2\) less 50N for every 30 by which the pitch exceeds 30°.

35.3.3.2 In the case of a roof to which there is access other than solely for the purposes of maintenance or repair the imposed load shall be taken as 1.44kN/m\(^2\).

### 35.3.4 Wind loads

35.3.4.1 Design wind loads shall conform to the appropriate requirements in Clause 17.9 of Part 17 this Code.

### 35.3.5 Deflections

35.3.5.1 The maximum deflection of structural members shall conform to Table 35.3.5.A. Dead loads need not be considered in computing such deflections.

<table>
<thead>
<tr>
<th>Structural</th>
<th>Type of ceiling supported</th>
<th>Maximum allowable deflection expressed as a Ratio of the Clear Span</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof rafter, roof joists, roof beams and roof decking of plank and beam construction</td>
<td>No Ceiling</td>
<td>1/180</td>
</tr>
<tr>
<td></td>
<td>Other than plaster</td>
<td>1/240</td>
</tr>
<tr>
<td></td>
<td>Plaster</td>
<td>1/360</td>
</tr>
</tbody>
</table>

### 35.3.6 Earthquake loads

35.3.6.1 Except for buildings of wood-frame construction, buildings shall be designed for the earthquake loads in Clause 17.10 of Part 17 of this Code, where the greatest horizontal area of the building above grade floor level, measured within the exterior surfaces of the exterior walls, exceeds 220m\(^2\).

35.3.6.2 Except as provided in Articles 35.3.6.3 to 35.3.6.5, 2 and 3 storey buildings in seismic zone 3 and 3-storey buildings in seismic zone 2 shall be designed for the earthquake loads in Clause 17.10 of Part 17 of this Code where the greatest horizontal area of the building above grade floor level, measured within the exterior surfaces of the exterior walls, does not exceed 220m\(^2\).

35.3.6.3 Buildings with structural loadbearing precast concrete elements (normal or lightweight) shall have connections designed for the earthquake loads in Clause 17.10 of Part 5 of this Code.

35.3.6.4 Buildings constructed with loadbearing masonry walls which are required
to resist the earthquake loads specified in Articles 35.3.6.1. and 35.3.6.2 may, in lieu of engineered design, be reinforced as required in Subclause 35.16.11.

35.3.6.5 Buildings with structural systems of wood frame construction need not be designed for the earthquake loads in Clause 5.10 of Part 17 of this Code.

35.4 ROOM AND SPACE DIMENSIONS

35.4.1 General

35.4.1.1 This clause applies only to dwelling units that are intended for use on a continuing basis as the principal residence of the occupant.

35.4.1.2 Areas and dimensions of rooms and spaces may be less than required in this clause provided it can be shown to the satisfaction of the authority having jurisdiction that the rooms and spaces are adequate for their intended use, such as by the provision of built-in furniture to compensate for reduced sizes.

35.4.2 Ceiling heights

35.4.2.1 Room heights

Heights of rooms or spaces in residential occupancies shall conform to Table 35.4.2.A

Table 35.4.2.A – Ceiling heights
(Forming part of Article 35.4.2.1)

<table>
<thead>
<tr>
<th>Room heights</th>
<th>Minimum heights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living room or space, Dining room or space Kitchen or kitchen space</td>
<td>2.7m over at least 75 percent of the required floor area with a clear height of at least 2.4m at any point over the required area.</td>
</tr>
<tr>
<td>Bedroom or bedroom space</td>
<td>2.5m over at least 50 per cent of the required floor area or at least 2.4m over all of the required floor area. Any part of the floor having a clear height of less than 1.4m shall not be considered in computing the required floor area.</td>
</tr>
<tr>
<td>Unfinished basement or cellar including laundry area therein</td>
<td>2.1m under beams in laundry areas and in any location that would normally be used for passage to laundry and required storage areas.</td>
</tr>
<tr>
<td>Bathroom, water-closet room or laundry area above grade floor level</td>
<td>2.4m in any area where a person would normally be in a standing position</td>
</tr>
<tr>
<td>Passage, hall or main entrance and finished rooms not specifically mentioned above</td>
<td>2.4m</td>
</tr>
</tbody>
</table>

35.4.2.2 The clear height above and below a mezzanine floor assembly in all occupancies shall not be less than 2.0m unless otherwise permitted by the authority having jurisdiction.

35.4.2.3 The clear height in a storage garage shall not be less than 2.4m.

35.4.3 Living rooms or Spaces within dwelling units

35.4.3.1 Living room area

Living areas within dwelling units, either as separate rooms or in combination with other spaces, shall have at least 13.47m² of floor area and shall have no dimension less than 3m within the required areas. Where the area of a living space is combined with a kitchen and dining area, the living area alone in a bachelor dwelling unit shall be at least 11.15m².

35.4.4 Dining rooms or spaces within dwelling units

35.4.4.1 A dining space in combination with other space shall have a minimum floor area of 4.5m². Dining rooms not combined with other space shall have a minimum area of 6.50m².

35.4.4.2 Except as permitted in Article 35.4.4.3, a dining room or space combined with other space shall have no dimension less
than 2.3m within the required area measured between wall faces or a wall face and a built-in cabinet or appliance.

35.4.4.3 When a required dining area is provided in a kitchen or serves a bachelor dwelling unit, the minimum dimension of such space may be reduced to 1.7m.

35.4.5 Kitchen within dwelling units

35.4.5.1 Kitchen area
Kitchen areas within dwelling units either separate or in combination with other space shall have at least 7.5m² of floor area including the area occupied by the base cabinets, except that in bachelor dwelling units the minimum floor area shall be 4.0m².

35.4.5.2 At least 910mm clearance shall be provided in front of base cabinet, work surfaces, counter tops and appliances.

35.4.6 Bedroom or space in dwelling units

35.4.6.1 Main bedroom area
Except as provided in Article 35.5.6.3 at least one bedroom in every dwelling unit shall have at least 11.15m² of floor area where built-in cabinets are not provided and 10.10m² of floor area where built-in cabinets are provided. The minimum dimension within their required area shall be 2.7m.

35.4.6.2 Other bedroom areas
Except as provided in Article 35.4.6.3 additional bedrooms shall have at least 9m² of floor area where built-in cabinets are not provided and 8m² of floor area where built-in cabinets are provided. The minimum dimension within the required area shall be 2.44m.

35.4.6.3 Combination bedroom areas
Bedroom spaces in combination with other spaces shall have at least 5.05m² of floor area and have no dimension less than 1.98m within the required area.

35.4.7 Bathrooms and water-closet rooms

35.4.7.1 Bathroom areas
In every dwelling unit an enclosed space of a minimum of 3m² shall be provided to accommodate a bathtub or shower bath, water closet and lavatory basin.

35.4.7.2 At least 550mm clearance shall be provided in front of the tub or shower stall to an opposite wall face or 450mm in front to another fixture over at least 600mm length of the bathtub or shower.

35.4.7.3 The centre line of the water closet shall be at least 400mm away from an adjacent side wall and from a vanity. At least 450mm clearance shall be provided in front of the water closet to the opposite wall or another fixture.

35.4.7.4 The centre line of a lavatory basin shall be at least 400mm from an adjacent side wall. At least 550mm clearance shall be provided in front of the lavatory basin to an opposite wall or 450mm clearance in front to another fixture.

35.4.8 Hallway

35.4.8.1 Width of hallways
The width of a hallway within a dwelling unit shall be at least 1200mm.

35.5 DOORS

35.5.1 Door in fire separations
Requirements relating to doors in fire separating and means of escape shall conform to the appropriate requirements in Clause 35.8 and 35.9.

35.5.2 Required doors

35.5.2.1 Required doors in single dwelling units
A door shall be provided at each entrance to a dwelling unit, bathroom, water-closet room and shower room.

35.5.2.2 Required doors in multiple dwelling units
In buildings containing more than one dwelling unit, doors shall be provided at the exterior entrances, laundry or drying rooms, storage rooms, public water-closet rooms, recreation rooms and any other locations required by Clause 35.9.

35.5.3 Doorway sizes

35.5.3.1 Doorway openings
Doorway openings within dwelling units shall be designed to accommodate not less than the door sizes in Table 35.5.3.A for swing-type doors. Where folding doors are to be provided, the same openings apply.

Table 35.5.3.A - Doorway sizes


### Minimum size of doors

<table>
<thead>
<tr>
<th>At Entrance to</th>
<th>Width mm</th>
<th>Height m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwelling unit (required entrance), Vestibule or entrance hall</td>
<td>810</td>
<td>2.0</td>
</tr>
<tr>
<td>Stairs to a floor level that contains a finished space</td>
<td>810</td>
<td>2.0</td>
</tr>
<tr>
<td>All doors in at least one line of passage from the exterior to the basement</td>
<td>810</td>
<td>2.0</td>
</tr>
<tr>
<td>Utility rooms</td>
<td>610</td>
<td>2.0</td>
</tr>
<tr>
<td>Walk-in closet</td>
<td>610</td>
<td>2.0</td>
</tr>
<tr>
<td>Bathroom, water-closet, shower room</td>
<td>700</td>
<td>2.0</td>
</tr>
<tr>
<td>Rooms not mentioned above, exterior balconies</td>
<td>760</td>
<td>2.0</td>
</tr>
</tbody>
</table>

#### 35.5.2 Doors to water-closet rooms in public buildings shall not be less than 810mm in width and 2.0m in height.

#### 35.5.4 Exterior doors

**35.5.4.1** Exterior doors shall be at least 44mm thick, except that doors for secondary entrances serving single dwelling units or balconies may be 35mm thick if of solid wood, solid core or stile and rail construction.

**35.5.4.2** Storm or combination doors shall be at least 35mm thick for wood doors and 25mm for metal doors.

**35.5.4.3** Where an exterior door opening is not completely protected from driving rain, it shall be provided with a sill that slopes to the exterior and the sill caulked with suitable caulking to prevent entry of water.

**35.5.4.4** Wooden frames for exterior doors shall be treated with approved preservative. Steel frames for exterior doors shall be painted with a rust inhibitive paint or otherwise treated before erection to prevent corrosion.

#### 35.5.5 Interior doors

**35.5.5.1** Interior wood doors in dwelling units other than closet doors or cupboards doors shall be at least 35mm thick.

**35.5.5.2** Interior wood doors to rooms or spaces used for storage, laundry, drying, vestibules, recreation, kitchen areas or water closets in apartments, buildings but not within dwelling units shall be at least 44mm thick.

**35.5.5.3** Doors sited along escape shall be fitted with a vision panel of at least 150mm x 150mm.

#### 35.5.6 Glass

**35.5.6.1** Glass thickness and the size of glass for doors shall conform to Table 35.5.6.A

<table>
<thead>
<tr>
<th>Minimum Glass Weight</th>
<th>Minimum glass thickness</th>
<th>Maximum Perimeter, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>510 g</td>
<td>4.8mm</td>
<td>2.03</td>
</tr>
<tr>
<td>680 g</td>
<td>5.6mm</td>
<td>3.05</td>
</tr>
<tr>
<td>907 g</td>
<td></td>
<td>4.06</td>
</tr>
</tbody>
</table>

#### 35.5.6.2 Glass side lights greater than 460mm in width that could be mistaken for doors, glass in storm doors and glass in sliding doors within or at every entrance to a dwelling unit and in public areas shall be safety glass of the laminated or tempered type or shall be of wired glass.

#### 35.5.6.3 Glass in entrance doors to dwelling units and in public areas, other than the entrance doors described in Article 35.5.6.2 shall be safety glass or wired glass of the type described in Article 35.5.6.2 where the glass area exceeds 0.46m² and extends to less than 910mm from the bottom of the door.

#### 35.5.6.4 Mirrored glass doors may be used only at the entrance to clothes closets. Such
doors shall be reinforced with hardboard plywood or particleboard securely fastened to the back of the mirror unless the mirror is safety glass of the laminated or tempered type.

35.5.6.5 Except as provided in Article 35.6.5.3 every glass or transparent door accessible to and used by the public shall be equipped with hardware, bars, or other permanent fixtures designed so that the existence and position of such door will be readily apparent.

35.5.6.6 Glass other than safety glass shall not be used for a shower or bathtub enclosure.

35.5.7 Garage doors

35.5.7.1 Garage doors shall be not less than 2.44m wide for one car and 4.27m wide for 2-car width. The height of the clear opening with the door in the open position shall be not less than 1.93m. For parking garages, garage doors shall be not less than 3.0m wide for one-way traffic and 5 m for two-way traffic.

35.5.7.2 Wood doors shall be at least 44mm thick in side hinged or one piece overhead and not less than 35mm thick if clauseal overhead.

35.5.7.3 Steel and Aluminum doors shall be made with suitable braced frames clad with not less than 0.6mm galvanized steel prepared for paint or 0.8mm thick aluminum.

35.5.7.4 Overhead roller shatter doors shall have suitable springs or counter-balances and weather stops.

35.6 WINDOWS

35.6.1 Scope

35.6.1.1 Natural lighting

This clause applies to installation of windows and to the requirement for natural lighting to be provided by windows in residential occupancies.

35.6.1.2 Requirements for widows in relation to fire protection are described in Clause 35.9.

35.6.1.3 Ventilation

Requirements for ventilation are described in Clause 35.23.

35.6.2 General

35.6.2.1 Window design

Windows shall be designed and installed so that they shed water.

35.6.2.2 Minimum window glass area

Except as provided in 35.6.2.4 the minimum window glass area for rooms in buildings or residential occupancy or which are used for sleeping shall conform to Table 35.6.2.A. The unobstructed glass area of a door or skylight is considered equivalent to that of a window.

35.6.2.3 Windows in public spaces

Wherever practicable, windows shall be provided to light corridors, stair-ways and similar public space in buildings.

### Table 35.6.2.A
(Forming part of Article 35.6.2.2)

<table>
<thead>
<tr>
<th>Location</th>
<th>Unobstructed Glass area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laundry, basement recreation room, unfurnished basement or cellar</td>
<td>4 per cent of area served</td>
</tr>
<tr>
<td>Water-closet room</td>
<td>0.37m²</td>
</tr>
<tr>
<td>Kitchen: Kitchen space Kitchen alcove</td>
<td>15 per cent of area served</td>
</tr>
<tr>
<td>Living rooms, dining rooms, bedrooms and other furnished rooms not mentioned above</td>
<td>15 per cent of area served</td>
</tr>
</tbody>
</table>

35.6.2.4 In areas deemed by the Authority having jurisdiction to have hot dry climates the minimum glass area shall be not less than 3 per cent (3%) of the area served.

35.6.3 Glass
35.6.3.1 Thickness of glass in windows shall conform to Table 35.6.3.A

Table 35.6.3.A
(Forming part of Article 35.6.3.1)

<table>
<thead>
<tr>
<th>Minimum Glass Weight</th>
<th>Minimum Glass Thickness</th>
<th>Sash type or Fixed Glazing</th>
</tr>
</thead>
<tbody>
<tr>
<td>510 gm</td>
<td>3.05m perimeter</td>
<td></td>
</tr>
<tr>
<td>680 gm</td>
<td>4.27m perimeter</td>
<td></td>
</tr>
<tr>
<td>907 gm</td>
<td>6.10m perimeter</td>
<td></td>
</tr>
<tr>
<td>5 mm</td>
<td>7 m perimeter</td>
<td>No limit</td>
</tr>
<tr>
<td>6 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-10 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

35.6.4 Sealing

35.6.4.1 Sealing

Sealant shall be provided between window frames or trim and the exterior siding or masonry.

35.6.5 Windows in Public areas

35.6.5.1 Transparent panels that could be mistaken as a means of escape shall be protected by barriers, railings or manifestation films.

35.6.5.2 Windows in exit stairways that extend to less than 1.07m, above the landing shall be protected by barriers or railings approximately 1.07m above such landings.

35.6.5.3 Sliding glass partitions which separate a public corridor from an adjacent occupancy and which are open during normal working hours need not conform to Article 35.6.5.1 and 35.5.6.5.

35.7 STAIRS, RAMPS, HANDRAILS AND GUARDS

35.7.1 Scope

35.7.1.1 Design and construction of stairs

This Clause applies to the design and construction of interior and exterior stairs, steps, ramps, railings and guards.

35.7.1.2 Stairs as part of exit

Where the stair forms part of an exit, the appropriate requirements in Clause 35.8 shall also apply.

35.7.1.3 Escalators and moving walkways shall conform to the appropriate requirements in Part 3 of this Code.

35.7.2 General

35.7.2.1 Definitions

(1) ‘Common Stairway’ means an internal or external stairway of steps with straight nosings on plan which forms part of a building and is intended for common use in connection with two or more dwellings.

‘Notional width’ has the meaning ascribed to it in Article 35.7.2.1 (2) c.

‘Parallel step’ means a step of which the nosing is parallel to the nosing of a step or landing next above it (Fig. 35.7.2.A).

‘Pitch line’ means a notional line drawn from the floor or landing below a stairway to connect the nosings of all the treads in a flight of stairs (Fig. 35.7.2.B).

‘Private stairway’ means an internal or external stairway of steps with straight nosings on plan which forms part of a building and is either within a dwelling or intended for use solely in connection with one dwelling.

‘Tapered steps’ means a step, the nosing of which is not parallel to the nosing of a step or landing next above it.

(2)(a) The going of a step shall be measured on plan between the nosing of its tread and the nosing of the tread of step or landing next above it (Fig. 35.7.2C)

(b) Except as provided in (c) the width of a stairway shall be measured between the centre line of the handrail on the one side and on the other side the centre line of the handrail, or, if there is no handrail the surface of the wall, screen or balustrade facing the stairway or railing (Fig. 35.7.2D)

(c) If a stairway contains consecutive tapered steps of differing widths, all such tapered steps shall be deemed to have a notional width equal to the width of the narrowest part of those tapered steps, measured from the side of the stairway where the steps are narrower (Fig. 35.7.2E).
35.7.2 Treads and risers shall have uniform rise and goings in any one flight for every parallel step.

35.7.2.3 Any private or common stairway shall be so constructed that over the whole width or, in case of tapered steps the notional width of stairway, there is:

(i) headroom of not less than 2m measured vertically above the pitch line; and

(ii) clearance of not less than 1.5m measured at right angles to the pitch line.

35.7.2.4 Any private or common stairway shall be so constructed that the nosing of the tread of any step or landing which has no riser below it overlaps, on plan, the back edge of the tread of the step below it by not less than 16mm (Fig.35.7.2 F).

35.7.2.5 Except for interior stairs within a dwelling unit, at least three risers shall be provided for interior stairs.

35.7.2.6 Interior stairs extending through the roof of a building shall be protected from rain.
Fig. 35.7.2
35.7.3 Private stairways

35.7.3.1 Any private stairway shall be so constructed that the sum of the going of a parallel step plus twice its rise is not less than 550mm and not more than 700mm.

35.7.3.2 The rise of a step shall be not more than 175mm and the thread of a step not less than 220mm (Fig.35.7.3A)

35.7.3.3 A private stairway shall contain no tapered steps except as permitted by subclause 35.7.5

35.7.4 Common stairways

35.7.4.1 Any common stairway shall be so constructed that the sum of the going of a parallel step plus twice its rise is not less than 550mm and not more than 700mm.

35.7.4.2 The rise of a step shall be not more than 190mm and the going of a step not less than 230mm. (Fig. 35.7.4A).

35.7.4.3 The pitch of any common stairway shall not be more than 38°.

35.7.4.4 A common stairway shall have not more than 16 rises in any flight.

35.7.4.5 A common stairway shall contain no tapered steps except as permitted by subclause 35.7.5.
Fig. 35.7
35.7.5 Tapered steps

35.7.5.1 The going and pitch of tapered steps shall be measured in the vertical planes of the pitch lines connecting the nosings of consecutive steps at a distance of 270mm from the extremities of the width (or where applicable, the notional width) of such steps.

35.7.5.2 The sum of the going plus twice the rise shall be not less than 550mm and not more than 720mm (Fig. 35.7.5A).

35.7.5.3 Any private or common stairway may include tapered steps so constructed that the greatest and least goings of consecutive tapered steps are uniform.

35.7.5.4 Tapered steps in a private or common stairway shall have the width of the nosing of the lowest of any consecutive tapered steps equal to the width of the nosing of the parallel step or landing next above such tapered steps (Fig. 35.7.5B).

35.7.5.5 Any private stairway which is not less than 750mm or more than 1m wide may include tapered steps so constructed that the nosing of the tread of any such step makes a uniform angle on plan of not less than 20° with the nosing of the tread of the step or landing next above it.

35.7.5.6 Any tapered steps in a private stairway shall have a going not less than 75mm throughout its actual width and a rise of not more than 220mm if the private stairway is not less than 750mm or more than 1m wide.

35.7.5.7 Any tapered steps in a private stairway shall have its least going uniform with that of any consecutive tapered step.

35.7.5.8 Any tapered steps in a private stairway shall have the width of the nosing of the lowest of any consecutive tapered steps equal to the width of the nosing of the parallel step or landing next above such tapered steps (Fig. 35.7.5C).

35.7.6 Landings

35.7.6.1 Landings

Landings shall be at least as wide and as long as the width of stairs in which they occur, except that the length of landing for exterior stairs serving not more than one dwelling unit shall not be less than 900mm and the length of landing for all other stairs in a straight run shall not be less than 1.2m

35.7.6.2 Door Swing on Stairs

Where a door swings towards a stair, the full arc of its swing shall be over a landing. Except as provided in Article 35.7.6.3, a landing shall be provided at the top and bottom of each flight of interior stairs and, where a doorway occurs, in a stairway.

35.7.6.3 Where a door occurs at the top of the stair in a dwelling unit, no landing is required between the doorway and stairs.

35.7.6.4 A landing shall be provided at the top of all exterior stairs, except that a landing may be omitted at a secondary entrance to a building containing a single dwelling unit provided the stair does not contain more than 3 risers.

35.7.6.5 The clear height over landings shall be at least 2m.

35.7.7. Ramps

35.7.7.1 Maximum gradient for ramps

The maximum gradient for pedestrian ramps shall be 1 in 5 for mercantile or industrial occupancies and 1 in 8 for all other occupancies. The gradient for every exterior ramp shall be 1 in 10. Maximum gradient of ramps for disabled persons are as given in in this Code.

35.7.7.2 Level area in ramps

Where a doorway or stairway opens onto the side of a ramp there shall be a level area extending across the full width of the ramp and for a distance of at least 300mm on either side of the opening.

35.7.7.3 Where a doorway or stairway opens onto the end of a ramp, there shall be level area extending across the full width of the ramp and along the ramp for at least 610mm.

35.7.8 Handrails

35.7.8.1 Any flight of steps in a private or common stairway with an aggregate rise of more than 600mm shall have a continuous handrail fixed securely at a height of not less than 900mm nor more than 1m measured vertically above the pitch line:

a) on each side of the stairway, if the least width of the stairway is 1m or more; or

b) on one side of the stairway, in any other case (Fig. 35.7.8A).
35.7.8.2 A clearance of at least 30mm shall be provided between each handrail and the wall to which it is fastened.

35.7.8.3 Handrails shall be so constructed that there will be no obstruction on or above them to break a handhold.

35.7.8.4 Handrails and stair stringers shall not project more than 90mm into the required width of stairway.

35.7.9 Guards

35.7.9.1 Every exterior landing, porch and every balcony, mezzanine, gallery, raised walkway roof of other external area to which access is provided for other than for maintenance purposes, shall be protected by guards on all open sides where, the difference in elevation between adjacent levels exceeds 600mm.

35.7.9.2 Any private stairway of common stairway shall be guarded on each side by a wall or be protected by guards extending to a height of not less than 850mm measured vertically above the pitch lines.

35.7.9.3 Except as provided in Article 35.7.9.4 all guards including those for balconies shall be at least 1.1m in height.

35.7.9.4 Guards to a landing or similar space forming part of a stairway shall be at least 900mm in height in the case of a private stairway or 1.1m in height in the case of a common stairway.

35.7.9.5 Openings through a guard on a balcony or an exit stair, except on an exit stair serving not more than one dwelling unit, shall be of a size as to prevent the passage of a spherical object having a diameter of 100mm in residential occupancies and 150mm in other occupancies, unless it can be shown to the satisfaction of the authority having jurisdiction that the location and size of such openings which exceed the limit do not represent a hazard.

35.7.9.6 Guards around exterior balconies of buildings of residential occupancies shall be designed so that no member, attachment or opening located between 100mm and 1.1m above the balcony floor will facilitate climbing.

35.7.10 Construction

35.7.10.1 Wooden stair stringers

Wooden stair stringers shall have a minimum effective depth of 90mm and an overall depth of a least 235mm. Stringers shall be supported and secured top and bottom. Stringers shall be at least 25mm actual thickness if supported along their length and 40mm actual thickness if unsupported along their length. Stringers shall be spaced not more than 900mm o.c (on centres) in dwelling units and 600mm o.c. when located in other than dwelling units, except that in dwelling units where risers support the front portion of the tread, the space between stringers shall not exceed 1.20m unless the stringers are designed for wider spacings.

35.7.10.2 Wooden treads

Timber or plywood treads for stairs within dwelling units shall be at least 25mm actual thickness except that if open risers are used, and the distance between stringers exceeds 760mm, the treads shall be at least 40mm actual thickness.

35.7.10.3 Tread finish

The finish for treads and landings of interior stairs in dwelling units, other than stairs to unfinished basements and cellars, shall consist of hardwood, resilient flooring or other material providing equivalent performance.
35.7.10.4 Non-skid finish

The finish for treads and landings of interior and exterior stairs, other than those in dwelling units shall have a non-skid finish or shall be provided with non-skid strips.

35.8 MEANS OF ESCAPE

35.8.1 Scope

35.8.1.1 This Clause applies to requirements that are designed to permit the safe and convenient access to the exterior of a building, to a public thoroughfare or to approved open space.

35.8.1.2 Stairways handrails and guards in a means of escape shall conform to the requirements in Clause 35.8 as well as requirements in this clause.

35.8.2 General

35.8.2.1 Exits shall be provided from every floor area. Except for mezzanines that are not enclosed and are of a size permitted in Table 35.8.6 A to have a single escape, mezzanines shall be provided with exits on the same basis as required for floor areas in this clause.

35.8.2.2 An access to exit shall be provided from every roof intended for occupancy and from every podium, terrace, platform or contained open space. Where a roof is intended for an occupant load of more than 60 persons, at least 2 separate means of escape shall be provided from the roof to stairs designed in conformance with the requirements for exit stairs and located remote from each other.

35.8.2.3 Exits may consist of doorways, passage ways, ramps, stairways, horizontal exits and escalators provided that where escalators are used as required exits, they are capable of moving only in the direction of exit travel.

35.8.2.4 Elevators or windows shall not be considered as being part of a required means of escape.

35.8.2.5 An exit shall be designed for no purpose other than for exiting except that an exit may also serve as an access to a floor area.

35.8.3 Dimensions of means of escape

35.8.3.1 This subclause applies to every means of escape except exits that serve not more than one (1) dwelling unit and access to exits within dwelling units.

35.8.3.2 The occupant load of floor areas or part of floor areas used in determining the minimum required width of a means of escape shall be the number of persons for which such areas are designed but not fewer than that determined from Table 35.8.3A.

35.8.3.3 Exit width

Except as provided in Subclause 35.8.5, the width of an exit corridor shall be at least 1.12m and width of other exits at least 915mm unless greater widths are required because of the occupant load. In computing the exit width on the basis of occupant load, the minimum aggregate width of exterior exit doors shall be 1 unit (see Article 35.8.3.6) per 90 persons, and the minimum aggregate width of other exits shall be 1 unit per 30 persons for residential occupancies and 1 unit per 60 persons for other occupancies.

35.8.3.4 Access to exit width

Except as provided in Subclause 35.8.5 the minimum width of a doorway corridor or passageway in an access to exit shall be 1 unit (see Article 35.8.3.6) per 90 persons but in no case shall the minimum width of a public means of escape be less than 1.20 m.

Table 35.8.3.A

Forming part of Article 35.8.3.2

Maximum area per person to be assumed in calculating occupant load

<table>
<thead>
<tr>
<th>Occupancy or Use of Floor Area</th>
<th>Maximum Area per person m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td></td>
</tr>
<tr>
<td>Dwelling units</td>
<td>(1)</td>
</tr>
<tr>
<td>Dormitories</td>
<td>4.65</td>
</tr>
<tr>
<td>Business and personal services</td>
<td></td>
</tr>
<tr>
<td>Shops</td>
<td>4.65</td>
</tr>
<tr>
<td>Offices</td>
<td>9.29</td>
</tr>
<tr>
<td>Mercantile</td>
<td></td>
</tr>
<tr>
<td>Retail sales floors at ground-floor, cellar or basement</td>
<td>2.79</td>
</tr>
<tr>
<td>Other mercantile uses</td>
<td>5.57</td>
</tr>
</tbody>
</table>
Industrial/ Factory
  Manufacturing or process rooms  4.65
  Storage garage  46.45
  Warehouse storage space  27.87
  Other storage space  46.45
  Aircraft hangers

Other Uses
  Cleaning and repair  4.65
  Kitchens  9.29

Note to Table 7.8.3.A
(1) Occupant load shall be based on two persons per bedroom or sleeping area.

35.8.3.5 Except as provided in Subclause 35.8.5, the minimum width of a stairway or ramp in an access to exit shall be 1 unit, as specified under Article 35.8.3.6, per 60 persons.

35.8.3.6 Calculation of units of exit width
The units or exit width in Articles 35.8.3.3 to 35.8.3.5 shall be determined by dividing the width (in mm) of exit by 560. Where the remainder is less than 300mm, it shall not be considered as contributing to the number of units. Where the remainder is 300mm or more, it shall be considered as contributed ¼ unit of exit width in the case of stairs and ½ unit of exit in the case of other exit facilities.

35.8.3.7 Aggregate width of exits
Where an exit serves more than 1(one) floor area, the aggregate width of such exit need not be cumulative from floor to floor except that where exits from above or below converge at an intermediate level, the width beyond the convergence in the direction of exit travel shall be not less than the aggregate required width of the converging exits.

35.8.3.8 Height of means of escape
Except as provided in Subclause 35.8.5 and Article 35.8.3.7 the minimum height of exits and corridors which provide access to exits shall be 2.15m.

35.8.4 Obstructions and hazards in means of escape

35.8.4.1 Scope
This subclause applies to obstructions and hazards in every means of escape except those within a dwelling unit or not serving not more than 1 dwelling unit.

35.8.4.2 Occupancies in public corridors
Where a public corridor or corridor used by the public contains an occupancy, such occupancy shall not reduce the unobstructed width of the corridor less than the required width of the corridor.

35.8.4.3 Obstructions in exits
Except as permitted in Subclause 35.8.5 and Article 35.7.8.4, no fixture turnstile or construction shall project within the required width of exit.

35.8.4.4 In any mercantile occupancy, no obstruction such as posts or turnstiles shall be placed so as to restrict the width of a normal means of escape from a floor area or part of a floor area to less than 760mm unless an alternate means of escape is provided adjacent to and is plainly visible from the restricted escape.

35.8.4.5 Mirrors in exits
No mirror shall be placed in or adjacent to any exit so as to confuse the direction of exit, and no mirror or draperies shall be placed on or over exit doors.

35.8.4.6 Appliances in a means of escape
Fuel-fired appliances shall not be installed in an exit or corridor serving as an access to exit.

35.8.4.7 Service rooms containing equipment subject to possible explosion and certain types of refrigerating and transformer equipment shall not be located under required exits.

35.8.5 Door in means of escape

35.8.5.1 Scope
This subclause applies to all doors in a means of escape except exterior doors serving not more than 1 dwelling unit unless otherwise stated herein.

35.8.5.2 Door obstructions
Exit doors shall not decrease the required exit width by more than 50mm for each full unit of exit width (560mm) and where such doors lead out of stairs or ramps in the direction of exit travel they shall not be less than ¾ of the width of such stairs or ramps.
35.8.5.3 Doors over landings

Doors in their swing shall not reduce the effective width of exit stairs or landings to less than 760mm nor shall they reduce the effective width of an exit passageway to less than the required width.

35.8.5.4 Door closure headroom

No door closer or other device shall be installed in an exit in such a manner as to reduce the head room clearance to less than 1.98m.

35.8.5.5 Door height and width

An exit door or a door that opens to or is located in a public corridor or other facility providing access to exit from individually rented rooms, suites of rooms or dwelling units shall be not less than 2.05m in height. Except as required in Articles 35.5.3.1 and 35.8.5.2, such doors shall be at least 815mm in width when only one (1) door leaf is installed in an opening and 610mm in width where more than one (1) door leaf is provided in the width of an opening. The width of an individual door leaf shall not exceed 1.22m in such opening.

35.8.5.6 Direction of door swing

Every door that opens onto a corridor or other facility that provides access to exit from a room or suite of rooms where such room or suite of rooms is used or intended for use by more than sixty (60) persons; and every door that is located within a corridor that is required to be separated from the remainder of the floor area by a fire separation, shall swing on a vertical axis in the direction of exit travel and shall not open onto a step.

35.8.5.7 Size of landings

Where an exit door opens onto a landing, the landing shall be not less than 300mm wider and longer than the width of the door. Such doors either in the open or closed position shall not be closer than 300mm to the nearest riser.

35.8.5.8 Exit door swing

Every required exit door including an exit door serving not more than one (1) dwelling unit shall swing on a vertical axis. Such door shall open in the direction of exit travel except that a door serving not more than one (1) dwelling unit is permitted to swing inward.

35.8.5.9 Revolving doors

Revolving doors used as exits shall be of an approved collapsible type, and shall be permitted only at ground floor level away from the foot of any stairway. Not more than ½ unit of exit width may be assumed for such doors.

35.8.5.10 Automatic locking prohibited

Except for hotels and motels, a door opening into a public corridor which provides access to exit from individually owned or rented rooms, suites of rooms or dwelling units shall be designed not to lock automatically when such doors are equipped with automatic self-closing devices.

35.8.6 Exits from floor areas

35.8.6.1 Number of exits

Except as provided in Article 35.8.6.6 and 35.8.6.7, at least two (2) exits shall be provided from every storey space so that the travel distance to the nearest exit shall be not greater than 38.0m in the case of business and personal services occupancies and 30.5m for all other occupancies (see Article 35.8.6.2 for explanation of travel distance).

35.8.6.2 Travel distance

For the purpose of this Subclause, travel distance means the distance from any point in the floor area to an exit measured along the path of exit travel, except that when a floor area is subdivided into individually owned or rented rooms, suites of rooms or dwelling units, and is served by a corridor required to provide a fire separation from such adjacent rooms, suites of rooms or dwelling units or by an exterior passageway, the travel distance shall be measured from the door of such rooms, suites of rooms or dwelling units to the nearest exit.

35.8.6.3 Horizontal exits

Not more than ½ the required exits from a floor area may be horizontal exits.

35.8.6.4 Size of Exits

Where more than one (1) exit is required from an area, each exit shall be considered as contributing not more than ½ the required units of exit width.

35.8.6.5 Distance between exits

Where more than one (1) exit is required from a floor area, at least two (2) exits shall be independent of each other and be placed remote from each other along the path of travel between them.

35.8.6.6 Single exit permitted

In buildings one (1) and two (2) storeys in building height, a single exit is permitted from each storey provided the floor area and travel distance requirements conform to Table 35.8.6.A.

Table 35.8.6.A (Forming part of Article 35.8.6.6)

1248
### Single exits from floor areas

<table>
<thead>
<tr>
<th>Occupancy of Floor Area</th>
<th>Maximum Floor Area (m²)</th>
<th>Maximum Travel Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2), (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td>92.90</td>
<td>15.24</td>
</tr>
<tr>
<td>Group B</td>
<td>185.81</td>
<td>22.86</td>
</tr>
<tr>
<td>Group M</td>
<td>139.35</td>
<td>15.24</td>
</tr>
<tr>
<td>Group F</td>
<td>139.35</td>
<td>10.67</td>
</tr>
</tbody>
</table>

**Notes to Table 7.8.6.A**

1. See Article 7.8.6.2 for explanation of travel distance.

2. Single exit permitted only when such exit is an exterior door at or near ground level.

3. See Article 7.8.6.7 for dwelling units.

#### 35.8.6.7 Exits for dwelling units

A dwelling unit containing more than one storey shall have an exit or doorway onto a public access to exit from each of its top and bottom storeys except that a single exit is permitted from a dwelling unit provided the exit is an exterior door leading directly from a storey of the dwelling unit at or near grade. The floor level of the uppermost storey of such dwelling unit shall not be more than 6.10m above the floor level of the storey containing the exit.

#### 35.8.6.8 Exits through lobbies

Not more than one (1) exit from a floor area above or below the main entrance doorway shall lead through the lobby. Such lobby shall be not more than 4.60m above grade floor level, and the path of travel through the lobby shall not exceed 15.25m. The lobby shall conform in all respects with the requirements for exits, except that rooms other than garbage rooms, boiler rooms and rooms containing a residential occupancy may open directly onto such lobby.

#### 35.8.7 Exit signs

**35.8.7.1 Scope**

This subclause applies to all exits except those serving not more than one (1) dwelling unit.

**35.8.7.2 Location**

Exits shall be located so as to be clearly visible or their location shall be clearly indicated.

**35.8.7.3** Except for the main entrance door to a building, every exit in a 3-storey building having an occupant load greater than 120, shall have an exit sign over it.

**35.8.7.4 Exit direction sign**

Exit direction signs shall be placed in corridors and passageways where necessary to indicate the direction of exit travel.

**35.8.7.5** Exit signs shall be installed so as to be visible from the exit approach. Such signs shall have the word “EXIT” in green letters on a contrasting background or white letters on a green background when the sign is internally lighted, and white letter on a green background or green letters on a white background when the sign is externally lighted. Lettering shall be made with at least 20mm-wide strokes and be at least 150mm high when the signs are externally lighted, and at least 115mm high if the sign is internally lighted.

**35.8.7.6 Exit lighting**

At least one emergency lighting shall be provided along the escape route.

#### 35.9 FIRE HAZARD PROTECTION

**35.9.1 Scope**

**35.9.1.1 Scope of fire protection**

This clause contains requirements to protect lives of the occupants and also resist the spread of fire to other buildings.

**35.9.2 Spatial separations between buildings**

**35.9.2.1** Except as provided in Article 35.9.2.2, the maximum percentage of unprotected openings in an exposing building face shall conform to this Code.

**35.9.2.2** Where a volunteer fire department is not available, the limiting distance determined from Article 35.9.2.1 shall be doubled.

**35.9.3 Firefighting equipment**

There shall be portable fire extinguishers, hose rails and other suppressing systems where applicable.

**35.9.4 Fire detection**

There shall be smoke detectors, core points, sounders and control panel where applicable.

#### 35.10 SITE PREPARATION

**35.10.1 General**

**35.10.1.1** The top soil and vegetable matter in all unexcavated areas under a
building shall be removed. All stumps, roots and other wood debris shall be removed from the soil to a minimum depth of 300mm in unexcavated areas under a building.

35.10.1.2 The bottom of every excavation shall be free of all organic materials.

35.10.1.3 Water removed
Excavations shall be kept free of standing water.

35.10.2 Backfill

35.10.2.1 Placing
Backfill shall be placed to avoid damaging the drainage tile or the water proofing of walls

35.10.2.2 Grading
Backfill shall be graded to prevent drainage towards the foundation after settling.

35.10.2.3 Boulders
Backfill within 60mm of the foundation shall be free of deleterious debris and boulders larger than 250mm diameter.

35.11 WATER-PROOFING AND DAMP PROOFING

35.11.1 General

35.11.1.1 Water-proofing of walls
Where hydrostatic pressure occurs, floors on ground and exterior surface of walls below ground level shall be waterproofed.

35.11.1.2 Damp proofing of Walls
Where hydrostatic pressure does not occur and the exterior finished ground level is at a higher elevation than the ground level inside the foundation walls, the exterior surface of foundation walls below ground level shall be damp proof.

35.11.1.3 Any part of a building next to the ground shall have a floor which is so constructed as to prevent the passage of moisture from the ground to the upper surface of the floor.

35.11.1.4 Any floor which is next to the ground shall be so constructed as to prevent any part of the floor being adversely affected by moisture or water vapour from the ground.

35.11.1.5 No hardcore laid under a floor which is next to the ground shall contain water-soluble sulphates or other deleterious matter in such quantities as to be liable to cause damage to any part of the floor.

35.12 DRAINAGE

35.12.1 Scope

35.12.1.1 Drainage
This Clause applies to subsurface drainage and to surface drainage

35.12.1.2 Floor Slabs
Drainage requirements beneath floor slabs shall conform to Clause 35.14.

35.12.2 Installation

35.12.2.1 Drain tile or pipe shall be laid on firm, undisturbed or well compacted soil.

35.12.2.2 Granular cover
The top and sides of drain pipes shall be covered with not less than 150mm of crushed stone or other clean granular materials.

35.12.3 Drainage disposal

35.12.3.1 Drain pipes shall drain to a sewer, drain ditch or dry well.

35.12.3.2 Dry wells
Dry wells shall be not less than 4.60m from any building foundations and located so that drainage is away from the building. Dry wells may be used only when located in areas where the natural groundwater level is below the bottom of the dry well.

35.12.4 Surface drainage

35.12.4.1 Surface drainage
The building shall be located or the building site graded so that water will not accumulate at or near the building.

35.12.4.2 Surface drainage shall be directed away from the location of any water supply well or septic tank disposal bed.

35.12.4.3 Interference with surface drainage
Where runoff water from a drive way is likely to accumulate or enter a garage, a catch basin shall be installed to provide adequate drainage.

35.12.4.4 Downspouts
Where downspouts are provided and are not connected to a sewer, provisions shall be made to prevent soil erosion.
35.13 FOOTINGS AND FOUNDATIONS

35.13.1 Scope
This clause applies to foundations of cast-in-place concrete or unit masonry foundation walls and cast-in-place footings constructed on soils and where the building is of other than concrete or steel frame construction. Where the foundation consists of other materials such as precast concrete, steel or wood, the foundation shall be designed in conformance with the appropriate provisions of Part 5 of this Code.

35.13.2 General

35.13.2.1 The foundation of a building shall:

1) safely sustain and transmit to the ground the combined dead load, imposed load and wind or earthquake load in such a manner as not to cause any settlement or other movement which would impair the stability of, or cause damage to, the whole or any part of the building or of any adjoining building or works;

2) be taken to such a depth or be so constructed, as to safeguard the building against damage by swelling and shrinking of the subsoil; and

3) be capable of adequately resisting any attack by sulphates or any other deleterious matter present in the subsoil.

35.13.2.2 Deviation from specific requirements
The authority having jurisdiction may permit a foundation design to deviate from the requirements in this clause where it is designed for the existing conditions in accordance with accepted engineering practice or where past experience shows the foundation design to be adequate.

35.13.2.3 Concrete
Concrete shall conform to Clause 35.2. Concrete for unreinforced footings and foundation walls shall have a minimum (100mm cube) compressive strength of 7N/mm² after 28-days or in the proportion of 50 kg of cement to not more than 0.1m³ of fine aggregate and 0.2m³ of coarse aggregate.

35.13.2.4 Mortar, mortar joints and corbels
Mortar, mortar joints, corbelling and protection for unit masonry shall conform to Clause 35.16.

35.13.2.5 Piers
Where pier type foundations are used, the piers shall be designed to support the applied loads from the superstructure in conformance with good engineering practice.

35.13.2.6 Where piers are used as a foundation system in a building of one storey in building height, the piers shall be installed to support the principal framing members and shall be spaced not more than 3.60m apart along the framing, unless the piers and their footings are designed for larger spacing. The height of such piers shall not exceed three (3) times their least base dimension at the base of the pier. Where sandcrete block piers are used, and when the width of the building is 4.20m or less, they shall be laid with their longest dimension at right angles to the longest dimension of the building.

35.13.3 Footing (strip foundations)

35.13.3.1 Where required
Footings shall be provided under walls, pilasters, columns, piers and chimneys that bear on soil or rock.

35.13.3.2 If the foundations of a building are constructed as strip foundations of plain concrete situated centrally under the walls, the strip foundations shall rest on undisturbed soil or engineered fill or rock. There shall not be a wide variation in the type of subsoil within the loaded area and no weaker type of soil below the soil on which the foundations rest within such a depth as may impair the stability of the structure.

35.13.3.3 Footing width
The width of the strip foundations shall not be less than the width specified in Table 35.13.3.A in accordance with the related particulars specified in the Table.

35.13.3.4 Footing thickness
The thickness of the strip foundations shall not be less than its projection (45°) from the face of the wall or footing and shall in no case be less than 150mm.

35.13.3.5 Footing overlap
Where the strip foundations are laid at more than one level at each change of level, the higher foundations shall extend over and unite...
with the lower foundations for a distance not less than the thickness of the foundations and in no case less than 300mm.

35.13.3.6 Where there is a pier, buttress or chimney or chimney forming part of a wall, the foundations shall project beyond the pier, buttress or chimney on all sides to at least the same extent as they project beyond the wall.

35.14 SLABS ON GRADE
35.14.1 Scope
This clause covers the requirements of concrete slabs placed on the ground.

35.14.1.1 Slabs-on-grade
This clause applies to basement and cellar slabs and to floor slabs-on-grade with perimeter foundation walls that support the superstructure.

35.14.1.2 Design of floor slabs-on-grade
Floor slabs-on-grade without foundation walls to support the superstructure shall be designed for the existing soil conditions in accordance with approved engineering practice and past practice in the area in which the slab is to be built.

35.14.2 Slab supports
35.14.2.1 Granular fill
When granular fill is used beneath basement and cellar slab it shall consist of not less than 150mm of coarse granular material.

35.14.2.2 Hardcore
The hardcore beneath concrete slabs-on-grade shall be compacted. Not less than 150mm of coarse, clean granular material shall be provided beneath the slab and shall be compacted.

35.14.3 Damp-proofing and waterproofing
35.14.3.1 Damp-proofing and water-proofing of basement and cellar slabs and slabs-on-grade shall conform to Clause 35.11

35.14.4 Drainages
35.14.4.1 Uplift pressures
Where groundwater levels may cause uplift pressures against the bottom of slab below-grade, lateral drains (French drains) shall be installed under the slab or the slab be designed to resist such uplift pressures.

35.14.4.2 Drainage
The accumulation of water underneath a slab-on-grade shall be prevented by grading, drainage or other method.

35.14.4.3 Where floor drains are installed, the floor surface shall be so sloped that water will run off quickly.

Table 35.13.3.4
(Forming part of article 35.13.3.3)
Minimum width of strip foundation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Type of Subsoil</th>
<th>Field test applicable</th>
<th>Minimum width in millimeters for total load in kilonewtons per linear metre of loadbearing walling of not more than</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Rock</td>
<td>Requires at least a pneumatic or other mechanically operated pick for excavation</td>
<td>In each case equal to the width of wall</td>
</tr>
<tr>
<td>II</td>
<td>Gravel</td>
<td>Compact</td>
<td>Requires pick for excavation. Wooden peg 50mm square in cross-clause hard to drive beyond 150mm</td>
</tr>
<tr>
<td></td>
<td>Sand</td>
<td>Compact</td>
<td>250 300 400 500 600 650</td>
</tr>
<tr>
<td>III</td>
<td>Clay</td>
<td>Stiff</td>
<td>Cannot be moulded with finger and required a pick or pneumatic or other mechanically operated spade for its</td>
</tr>
<tr>
<td></td>
<td>Sandy Clay</td>
<td>Stiff</td>
<td>250 300 400 500 600 650</td>
</tr>
</tbody>
</table>
### 35.14.5 Thickness and height

#### 35.14.5.1 Thickness

Concrete slabs-on-ground shall not be less than 100mm thick exclusive of screed. The concrete shall be composed of cement, fine and coarse aggregates in the proportions of 50kg of cement to not more than 1.0m³ of coarse aggregates. When screed is provided it shall be not less than 20mm thick.

#### 35.14.5.2 Height above ground level

The top of every slab-on-grade shall be not less than 150mm above exterior finished ground level.

#### 35.14.6 Pipes and ducts

##### 35.14.6.1 Encasement of ducts

Ducts in slabs shall be completely encased with not less than 50mm of concrete, and installed so that water will not accumulate in the ducts.

##### 35.14.7 Joints

##### 35.14.7.1 Joints between slab-on-ground and foundation walls, and spaces around pipes, conduits or ducts that penetrate such slabs shall be filled with bitumen or other filler approved for this purpose.

### 35.15 COLUMNS

#### 35.15.1 Scope

This Clause applies to columns used to support carport roofs, and beams carrying loads from not more than 2 wood-frame floors where the length of joists carried by such beams does not exceed 4.80m and the live load on any floor does not exceed 2.5kN/m².

#### 35.15.1.1 Columns for applications other than as described in Article 35.15.1.1 shall be designed in accordance with approved engineering practice.

#### 35.15.2 General

##### 35.15.2.1 Column support

Columns shall be centrally located on a footing conforming to Clause 35.13.

##### 35.15.2.2 Columns shall be securely fastened to the supported member to prevent lateral movement.

#### 35.15.3 Steel columns

##### 35.15.3.1 Size

Except as permitted in Article 35.15.3.2, steel pipe columns shall have a minimum outside diameter of 75mm and a minimum wall thickness of 5.00mm.

##### 35.15.3.2 Exception

Columns of sizes other than as specified in Article 35.15.3.1 may be used where the loadbearing capacities are shown to be adequate.
35.15.3.3 Bearing plates

Except as permitted in Article 35.15.3.4, steel columns shall be fitted with not less than 100mm by 100mm by 6mm thick steel plates at each end, and where the column supports a wooden beam, the top plate shall extend across the full width of the beam.

35.15.3.4 Exception

The top plate required in Article 35.15.3.3 may be omitted where a column supports a steel beam and provision is made for the attachment of the column to the beam by welding or other approved method.

35.15.3.5 Rust prevention

Steel columns shall be treated on the outside surface with at least one coat of rust-inhibitive paint.

35.15.4 Wood columns

35.15.4.1 Scope

The width or diameter of a wood column shall be not less than the width of the supported member. Except as provided in Article 35.15.4.2, columns shall be not less than 200mm for round columns and 150mm by 150mm for rectangular columns, unless calculations are provided to show that lesser sizes are adequate.

35.15.4.2 Wood columns for garages and carports may be 100mm by 100mm.

35.15.4.3 Construction

Wood columns shall be either solid, glued-laminated or built-up. Built-up columns shall consist of not less than 50mm thick full-length members bolted together with not less than 10mm diameter bolts spaced not more than 450mm centres, or nailed together with not less than 75mm nails spaced not more than 300mm centres.

35.15.4.4 Dampproofing

Treated wood columns shall be separated from concrete in contact with the ground by an approved damp proofing material.

35.15.5 Unit masonry columns

35.15.5.1 Material

Unit masonry columns shall be built of loadbearing masonry units.

35.15.5.2 Size

Unit masonry columns shall have minimum nominal dimensions of 300mm by 300mm or 250mm by 400mm.

35.15.6 Solid concrete columns

35.15.6.1 Material

Concrete shall conform to Clause 35.2

35.15.6.2 Size

Concrete columns shall not be less than 200mm by 200mm for rectangular columns and 225 mm diameter for circular columns

35.16. MASONRY (BRICKS, BLOCKS OR SANDCRETE)

35.16.1 Scope

35.16.1.1 This Clause applies to unreinforced masonry and masonry finish in which the wall above the foundation does not exceed 7.60m and in which the roof or floor system above the first storey is not of concrete construction.

35.16.1.2 For buildings other than those described in Article 35.16.1.1 or where the masonry is designed on the basis of design loads and allowable stresses, structural members of unreinforced masonry shall conform to Eurocode 6-Design of unreinforced structures.

35.16.1.3 In Seismic Zone 3, loadbearing elements of masonry buildings more than one storey in height shall be reinforced with at least the minimum amount of reinforcement as required in Subclause 35.16.11.

35.16.1.4 In Seismic Zone 2, loadbearing elements of three storey masonry building shall be reinforced with at least the minimum amount of reinforcement as required in Subclause 35.16.11.

35.16.2 Masonry units

35.16.2.1 Materials specifications for masonry units

Masonry units shall comply with one of the following:

BS 3921: “Clay bricks and blocks”
BS 2028: “Precast concrete blocks”

35.16.2.2 Used masonry

Used bricks shall be free of old mortar, soot or other surface coating and shall conform to Article 35.16.2.1
35.16.2.3 Compressive strength
Except as provided in Article 35.16.2.1, the compressive strength of masonry units in a wall of a house of one or two storeys or of a building of one or two storeys which is divided into flats, shall not be less than 2.75N/mm² for blocks and 5.2N/mm² for bricks.

35.16.2.4 The compressive strength of bricks and blocks for non-loadbearing partitions shall not be less than 1.4N/mm² provided the bricks and blocks are satisfactory in other respects.

35.16.3 Mortar
35.16.3.1 Lime
Lime used in mortar shall be hydrated.

35.16.3.2 Mortar mixes
Mortar mixes shall conform to Table 35.16.3.A. Mortar containing Portland cement shall not be used later than 2½ hours after mixing.

<table>
<thead>
<tr>
<th>Permissible Use of Mortar</th>
<th>Cement</th>
<th>Lime</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>All locations</td>
<td>1</td>
<td>1</td>
<td>5 to 6</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>8 to 9</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-</td>
<td>5 to 6</td>
</tr>
</tbody>
</table>

35.16.4 Mortar joints
35.16.4.1 Mortar joint thickness
The maximum average joint thickness shall be 12mm. Maximum thickness of an individual joint shall be 20mm.

35.16.4.2 Solid masonry joints
Solid masonry units shall be laid with full head and bed joints.

35.16.4.3 Hollow masonry joints
Hollow masonry units shall be laid with mortar applied to head and bed joints of both inner and outer face shells.

35.16.5 Masonry support
35.16.5.1 Masonry support
All masonry shall be supported on masonry, concrete or steel.

35.16.5.2 Lintels
Masonry over openings shall be supported by steel, reinforced concrete or masonry lintels or arches designed to support the imposed load.

35.16.5.3 Every masonry wall shall be at least as thick as the wall it supports.

35.16.6 Thickness and height
35.16.6.1 Thickness of solid external walls
Masonry external walls other than cavity walls in one storey buildings and the top storeys of two storey buildings shall be not less than 140mm thick provided the walls are not more than 2.75m high at the eaves and 4.60m high at the peaks of gable ends. The external walls of the bottom storeys of two storeys buildings shall not be less than 215mm.

35.16.6.2 Thickness of interior walls
The thickness of loadbearing interior walls shall be determined on the basis of Article 35.16.9.1

35.16.6.3 Interior non-loadbearing partitions shall be not less than 70mm thick
(see Article 35.16.9.1).

35.16.6.4 Masonry finish
Masonry finish resting on a bearing support shall be of solid units not less than 75mm thick for wall heights up to 12m. Such finish over wood-frame walls shall have not less than a 25mm air space behind the finish. Masonry finish less than 90mm thick shall have unraked joints.

35.16.6.5 Parapet walls
The height of parapet walls above the adjacent roof surface shall not be less than three times the parapet wall thickness.

35.16.7 Chases and recesses
35.16.7.1 Size of chases and recesses
Except as permitted in Article 35.16.7.3, the depth of any chase or recess shall not exceed ⅓ the thickness of the wall and the horizontal projection of the chase or recess shall not exceed 500mm.

35.16.7.2 Location of chases and recesses
Chases and recesses shall be not less than four times the wall thickness apart and not less
than 600mm away from any pilaster, cross wall, buttress or other vertical element providing required lateral support for the wall.

35.16.7.3 Oversized chases and recesses
Chases or recesses that do not conform to the limits specified in Articles 35.16.7.1 and 35.16.7.2 shall be considered as opening and any masonry supported above such a chase or recess shall be supported by a lintel or arch.

35.16.8 Support of loads
35.16.8.1 Capping of walls
Loadbearing walls of hollow masonry units supporting roof or floor framing members shall be capped with not less than 50mm of solid masonry, or have the top course filled with concrete. Capping may be omitted where the framing is supported on a wood plate not less than 50mm thick, the same width as the masonry wall.

35.16.8.2 Bearing area
The bearing area under beams and joists shall be sufficient to carry the supported load. In no case shall the minimum length of end bearing of beams supported masonry be less than 90mm. The length of end bearing of floor, roof or ceiling joists supported on masonry shall be not less than 40mm.

35.16.9 Lateral support
35.16.9.1 Lateral support of masonry walls
Masonry walls and partitions shall be supported at right angles to the wall by floor or roof construction or by intersecting masonry walls or buttresses. The spacing of such supports shall conform to Table 35.16.9.A

35.16.9.2 Floor and roof constructions providing required lateral support for walls as required in Article 7.16.9.1 shall be constructed to transfer lateral loads to walls or buttresses approximately at right angles to the laterally supported walls.

<table>
<thead>
<tr>
<th>Type of wall</th>
<th>Maximum Spacing of Supports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loadbearing walls of solid units</td>
<td>20 times the wall thickness</td>
</tr>
<tr>
<td>Non-loadbearing walls or partitions</td>
<td>18 times the wall thickness</td>
</tr>
<tr>
<td>Non-loadbearing walls or partitions</td>
<td>36 times the wall thickness</td>
</tr>
</tbody>
</table>

35.16.10 Exterior finish
35.16.10.1 Sandcrete Block Exterior Finish
Above-grade external walls of sandcrete block shall be stuccoed, painted or otherwise finished to provide breather-type water repellency.

35.16.11 Reinforcement for earthquake resistance
35.16.11.1 Where reinforcement is required in this clause, masonry walls shall be reinforced horizontally and vertically with steel having a total cross-clauseal area of not less than 0.002 times the cross-clauseal area of the wall, so that not less than ⅓ of the required area is installed either horizontally or vertically and the remaining in the other direction.

35.17 WOOD-FRAME CONSTRUCTION
35.17.1 Scope
35.17.1.1 Wood-frame construction
This clause applies to conventional wood-frame construction in which the framing members are spaced not more than 600mm centres.

35.17.1.2 Design live load
The requirements in this clause with regard to floor framing, sub-flooring and their fastenings apply to floors for which the design live load does not exceed 2.5KN/m².

35.17.1.3 The requirement in this clause with regard to wall framing and its fastenings apply to walls which support floors for which the design live load does not exceed 2.5KN/m² on any floor.

35.17.1.4 Where the conditions in Article 7.17.1.2 or 7.17.1.3 are exceeded, the design of the framing and fastening shall conform to Part 5 of this Code.
35.17.1.5 Post, beam and plank construction and plank frame wall construction shall conform to this Code.

35.17.2 General
35.17.2.1 Rrigidity
All members shall be so framed, anchored, fastened, tied and braced to provide the necessary strength and rigidity.

35.17.2.2 Treatment of end members
Ends of wood joists or beams and other members framing into masonry or concrete shall be treated to prevent decay where the bottom of the member is at or below ground level, or a 15mm air space shall be provided at the end sides of the member.

35.17.2.3 Wood framing members that are not pressure treated with wood preservative and which are supported on a concrete in contact with the ground or fill shall be separated from the concrete by an approved damp proofing material, except that such damp proofing is not required where the wood member is a least 150mm above the ground.

35.17.3 Nails and staples
35.17.3.1 Nails and staples specification
Nails specified in this clause shall be common steel wire nails or common spiral nails unless otherwise indicated. Other nails providing at least equivalent performance may also be used.

35.17.3.2 Nail length
All nails shall be long enough so that not less than half their length penetrates into the second member. Splitting of wood members shall be minimized by staggering the nails in the direction of the grain and by keeping nails well in from the edges.

35.17.4 Allowable spans
35.17.4.1 The spans of wood joists, rafters and beams shall be determined in conformance with Part 5 of this Code.

35.17.5 Notching and drilling
35.17.5.1 Notches and drilling
Holes drilled in roof, floor or ceiling framing members shall be not larger than ¼ the depth of the member and shall be located not less than 50mm from the edges, unless the depth of the member is increased by the size of the hole.

35.17.5.2 Floor, roof and ceiling framing members may be notched provided the notch is located on the top of the member within ½ the joist depth from the edge of bearing and is not deeper than ½ the joist depth, unless the depth of the member is increased by the size of the notch.

35.17.5.3 Wall studs shall not be notched, drilled or otherwise damaged so that the undamaged portion of the stud is less than ½ the depth of the stud if the stud is loadbearing or 40mm if the stud is non-loadbearing, unless the weakened studs are suitably reinforced.

35.17.5.4 The top plates in loadbearing walls and partitions shall not be notched, drilled or otherwise weakened to reduce the undamaged width to less than 50mm, unless the weakened plates are suitably reinforced.

35.17.5.5 Roof truss members shall not be notched, drilled or otherwise damaged unless such notching or drilling is allowed for in the design of the truss.

35.17.6 Anchorage
35.17.6.1 Anchorage
Building frames shall be anchored to the foundation, unless a structural analysis of the wind and earth pressures shows anchorage is not required.

35.17.6.2 Anchorage shall be provided by embedding the ends of the ground floor joists in concrete, or fastening the sill plate to the foundation with not less than 13mm diameter anchor bolts spaced not more than 2.5m centres. Such anchor bolts shall be embedded no less than 100mm in the foundation and so designed that they may be tightened without withdrawing them from the foundation.

35.17.6.3 Exterior columns and posts shall be anchored to resist uplift and lateral movement.

35.17.7 Sill plates
35.17.7.1 Sill plates
Where sill plates provide bearing for the floor system, they shall be not less than 50mm by 100mm material.

35.17.7.2 Sill plates shall be levelled by setting them on a full bed of mortar, except that where the top of the foundation is level they may be laid directly on the foundation provided the
junction between the foundation and the sill plate is caulked.

35.17.8 Beams to support floors

35.17.8.1 Beams

Beams shall have even and level bearing to support floors. Beams shall have not less than 90mm length of bearing at end supports.

35.17.8.2 Built-up wood beams

Where a beam is made up of individual pieces of timber that are nailed together, the individual members shall be 50mm or greater in thickness and installed on edge.

35.17.8.3 Where the individual members of a beam described in Article 35.17.8.2 are butted together to form a joint, each such joint shall occur over a support or at or within 150mm of the end quarter points of the clear span of the beam.

35.17.8.4 Joints in individual members of beams that are located at or near the end quarter points described in Article 35.17.8.3 shall not reduce the effective beam width by more than half. Members joined at quarter points shall be continuous over the adjacent supports.

35.17.8.5 Except as provided in Article 35.17.8.6 where 50mm members are laid on edge to form a built-up beam, individual members shall be nailed together with a double row of nails at least 90mm in length, spaced not more than 450mm apart in each row with the end nails located 100mm to 150mm from the end of each piece.

35.17.8.6 Where 50mm members in built-up wood beams are not nailed together as provided in Article 7.17.8.5 they shall be bolted together with at least 13mm diameter bolts equipped with washers and spaced not more than 1.2m centres with the end bolts located not more than 600mm from the ends of the members.

35.17.9 Floor joists

35.17.9.1 Except when supported on ribbon boards, floor joists shall have not less than 40mm length of end bearing. Ribbon boards shall be not less than 25mm by 100mm timber let into the studs.

35.17.9.2 Floor joists may be supported on the top of beams or may be framed into the sides of beams.

35.17.9.3 When framed into the sides of a wood beam, the joists shall be supported on joist hangers or other acceptable mechanical connectors or on not less than 50mm by 75mm ledger strips nailed to the side of the beam.

35.17.9.4 Unless ceiling furring or plywood cladding is installed on the underside of floor joists, floor joists shall be restrained from twisting at the end supports and at intervals between supports not exceeding 2.10m. Such restraint may be provided at the end supports by toe nailing to the support, or by end nailing the joists to the header joist.

35.17.9.5 Double joists

Header joists around floor openings shall be doubled when they exceed 1.2m in length. The size of header joists exceeding 3.15m in length shall be determined by calculations.

35.17.9.6 Trimmer joists around floor openings shall be doubled when the length of the header joist exceeds 810mm. When the header joist exceeds 2.03m in length the size of the trimmer joists shall be determined by calculations.

35.17.9.7 Support of non-loadbearing partitions

Non-loadbearing partitions parallel to floor joists shall be supported on beams, loadbearing walls or double joists where the partition is over 1.8m in length and contains openings that are not full ceiling height. Where such partitions contain no openings or openings that are full ceiling heights, the joists need not be doubled. Non-loadbearing partitions less than 1.8m in length need not be supported on framing but may be supported by the subfloor. Doubled joists may be separated not more than 200mm by blocking, if the blocking is not less than 50mm by 100mm timber spaced not more than 1.2m apart.

35.17.9.8 Non-loadbearing partitions at right angles to the floor joists are not restricted as to location.

35.17.9.9 Support of loadbearing partitions

Loadbearing interior walls parallel to floor joists shall be supported by beams of walls of sufficient strength to transfer safely, the design loads to the vertical supports.

35.17.9.10 Location of loadbearing interior walls

Loadbearing interior walls at right angles to floor joists shall be located not more than
900mm from the joist supports when the wall does not support a floor, and not more than 600mm from the joist support when the wall supports one floor unless the joist size is designed to support such loads.

35.17.10 Wall studs

35.17.10.1 Wall studs

Wall studs shall be continuous for the full storey height except at openings and shall not be spliced.

35.17.10.2 Position of wall studs

Wall studs shall be placed at right angles to the wall face, except that studs on the flat may be used in gable ends of roofs that contain only unfinished space or in non-loadbearing partitions.

35.17.10.3 Design of corners and interclauses

Corners and interclauses shall be designed to provide adequate support for the vertical edges of interior and exterior cladding materials, and in no instance shall exterior corners be framed with less than the equivalent of two (2) studs.

35.17.10.4 Double studs

Except as provided in Article 35.17.10.5 studs shall be doubled on each side of openings so that the inner studs extend from the lintel to the bottom wall plate and the outer studs extend from the top wall plate to the bottom wall plate.

35.17.10.5 Single studs

Single studs may be used on either side of openings in non-loadbearing partitions provided the studs extend from the top wall plate to the bottom wall plate.

35.17.10.6 The size and spacing of studs shall conform to Table 35.17.10. A

<table>
<thead>
<tr>
<th>Type of wall</th>
<th>Supported (including dead loads)</th>
<th>Loads dead</th>
<th>Minimum stud size, mm</th>
<th>Maximum stud spacing, mm</th>
<th>Maximum unsupported height, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior</td>
<td>No load</td>
<td></td>
<td>50 by 50</td>
<td>400</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 by 100</td>
<td>400</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Roof load or limited attic storage plus 1 floor</td>
<td>50 by 100</td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 by 75</td>
<td>400</td>
<td>3.6</td>
</tr>
<tr>
<td>Exterior</td>
<td>Roof</td>
<td></td>
<td>50 by 75</td>
<td>400</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 by 100</td>
<td>400</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Roof</td>
<td></td>
<td>50 by 75</td>
<td>400</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 by 100</td>
<td>600</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Roof plus 1 floor</td>
<td></td>
<td>50 by 100</td>
<td>400</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 by 150</td>
<td>600</td>
<td>3.0</td>
</tr>
</tbody>
</table>

35.17.11 Wall plates

35.17.11.1 Wall plates

Wall plates shall be not less than 50mm thick and shall be the same width as the wall studs, except that in non-loadbearing partitions and in loadbearing walls where the studs are located directly over framing members, the bottom wall plate may be 20mm thick.

35.17.11.2 Bottom wall plates

A bottom plate shall be provided in all cases. The bottom plate in exterior walls shall not project more than ½ the plate width over the support.

35.17.11.3 Top plates in loadbearing walls

Except as permitted in Articles 35.17.11.4 and 35.17.11.5 no fewer than two top plates shall be provided in loadbearing walls and partitions.
35.17.11.4 A single top plate may be used in a clause of a loadbearing wall containing a lintel provided the top plate forms a tie across the lintel.

35.17.11.5 A single top plate may be used in loadbearing wall where the concentrated loads from ceilings, floors and roofs are not more than 50mm to one side of the supporting studs and in all non-loadbearing partitions.

35.17.11.6 Joints in top plates
Joints in top plates of loadbearing walls shall be staggered at least one (1) stud spacing.

35.17.11.7 Tying of top plates at corners
The top plates in loadbearing walls shall be lapped or otherwise suitably tied at corners and intersecting walls. Joints in single top plates used with loadbearing walls shall be suitably tied.

35.17.12 Framing over openings

35.17.12.1 Except as provided in Article 35.17.12.3 openings in non-loadbearing walls shall be bridged with not less than 50mm material the same width as the studs nailed to adjacent studs.

35.17.12.2 Openings in loadbearing walls shall be bridged with lintels designed to carry the super-imposed loads to adjacent studs. Except as provided in Article 35.17.12.3 where 2 or more members are used in lintels, they shall be fastened together with not less than 85mm nails in a double row, with nails not more than 450mm apart in each row. The lintel members may be separated by filler pieces.

35.17.12.3 In loadbearing exterior and interior walls of 50mm by 75mm framing members, lintels shall consist of solid 75mm thick members on edge or 50mm thick and 20mm thick members securely nailed together.

35.17.13 Bracing

35.17.13.1 Except as provided in Article 35.17.13.2 each exterior wall in each storey shall be braced with at least one (1) diagonal brace conforming to Article 35.17.13.3

35.17.13.2 Bracing is not required where walls are clad with panel type sheathing or panel type siding.

35.17.13.3 Where bracing is required, it shall consist of at least 25mm by 100mm wood members applied diagonally to the studs at an angle of approximately 45 degrees to the horizontal extending the full height of the wall on each storey. Such bracing shall be nailed to each stud and wall plate by at least two 63mm nails.

35.18 POST BEAM AND PLANK CONSTRUCTION

35.18.1 Scope
This clause applies to wood-frame construction with the loadbearing framing members spaced more than 600mm apart.

35.18.2 General

35.18.2.1 The size and spacing of posts and beams and the span and thickness of floor decking shall be calculated in conformance with Part 17 of the Code.

35.18.2.2 Requirement for nails, timber, notching and drilling anchorage and sill plates shall conform to Clause 35.17.

35.18.3 Decking

35.18.3.1 Specifications for floor and roof decking
Floor and roof decking shall consist of not less than 50mm timber laid on the flat or edge.

35.18.3.2 Plank floor decking
Plank floor decking laid on the flat shall be not more than 200mm wide. Such decking shall be tongued-and-grooved or splined unless a separate underlay is installed or the flooring consists of woodstrips laid at right angles to the decking.

35.18.4 Loadbearing beams

35.18.4.1 Loadbearing beams shall be solid, built-up, glued-laminated or plywood web beams.

35.18.4.2 Loadbearing roof beams shall be securely connected to the exterior wall framing and the centre loadbearing wall or centre beams to resist adequately the uplift forces due to wind.

35.18.4.3 The length of end bearings for loadbearing beams shall be determined on the
basis of allowable design stress of wood but not less than 40mm.

35.18.4.4 When loadbearing beams are supported by mechanical connectors, the connectors shall be capable of supporting the design loads.

35.18.4.5 Where joints in loadbearing beams do not occur over solid supports, joints shall be designed according to approved practice.

35.18.4.6 Opposing loadbearing beams shall be tied together at the joints by means of splices or suitable mechanical connectors.

35.18.4.7 Where secondary framing members span between floor beams, members and connections shall be designed to support the required design loads.

35.18.4.8 Loads from loadbearing walls, columns or other concentrated loads shall be supported by members designed to carry such loads.

35.18.5 Posts

35.18.5.1 Posts shall be solid, built-up or laminated.

35.18.5.2 Exterior wall post
Where wall sheathing does not provide suitable anchorage, exterior wall posts shall be anchored to the wall plate by not less than 1.2mm thick steel angles or other approved anchors.

35.18.5.3 Built-up posts
Solid posts and individual members in built-up posts shall extend in one piece the full height of the wall storey. Built-up members shall be fastened together with nails spaced not more than 300mm centres and at least twice as long as the individual member thickness, or with not less than 10mm diameter bolts fitted with washers and spaced not more than 450mm centres.

35.18.5.4 Intermediate studs
Intermediate studs or blocking shall be provided between posts in post and beam walls for the support of exterior and interior cladding. Intermediate studs shall conform to Clause 35.18 for non-loadbearing stud walls.

35.18.6 Plank frame wall construction

35.18.6.1 Thickness of plank framing in plank frame walls shall conform to Table 35.18.6A. The unsupported height of 50mm vertical plank non-loadbearing partitions shall not exceed 3.60 m.

35.18.6.2 Vertical framing in plank frame walls shall consist of not less than 250mm wide planks spaced not more than 2.40m centres.

Table 35.18.6.A
(Forming Part of Article 35.18.6.1)
Nominal thickness of plank framing

<table>
<thead>
<tr>
<th>Supported load (including dead load and ceiling)</th>
<th>Minimum Plank thickness, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof with or without attic storage</td>
<td>50</td>
</tr>
<tr>
<td>Roof with or without attic storage plus one (1) floor</td>
<td>50</td>
</tr>
<tr>
<td>Roof with or without attic storage plus two (2) floors</td>
<td>75</td>
</tr>
</tbody>
</table>

35.18.6.3 Vertical framing in plank frame walls shall not bear on wood members with the grain at right angles to the vertical framing except where bearing on sills.

35.18.6.4 Corners of plank frame walls shall be formed by butting and fastening together the face and edge of two planks.

35.18.6.5 Vertical framing in plank frame walls shall be provided on each side of every opening, except that a window opening more than 750mm in width may be supported on one side only by a vertical member. In such cases, the opposite jamb of the window or short upright to which it is attached shall bear on the filler wall plank immediately below, which in turn shall be notched into the vertical structural members on each side.

35.18.6.6 Where horizontal planks act as loadbearing lintels or headers, they shall be
framed into the vertical members by dovetailing so that not less than a 40mm length of bearing is provided.

35.18.6.7 Openings in loadbearing plank frame walls shall be bridged with lintels designed to carry superimposed loads to adjacent members.

35.18.6.8 Non-loadbearing horizontal members (fillers) in plank frame walls shall be securely fastened to the vertical framing.

35.19 ROOFING

35.19.1 General

35.19.1.1 Roof protection

Roof shall be protected with roofing, including flashing, installed to shed rain effectively.

35.19.2 Roofing materials

35.19.2.1 Materials specification

Roofing materials shall conform to the following:

BS. 5247: Part 14: 1975, Code of Practice for sheet roof and wall coverings-
BS. 690 Part 4: 1974, Specification for asbestos – cement slates and sheets
BS 402: 1974, Specifications for clay plain roofing tiles and fittings.

35.19.2.2 Roofing nails

Nails used for roofing shall be corrosion-resistant roofing or shingles nails. Nails shall have sufficient length to penetrate through or 12mm into roof sheathing. Nails used with wood shingles or shakes shall have a head diameter of not less than 5mm and a shank thickness of not less than 2mm.

35.19.2.3 Roofing staples

Staples used to apply wood shingles shall be corrosion-resistant and shall be driven with the crown parallel to the eaves. Staples used with wood shingles shall be not less than 30mm long, 2mm diameter or thickness, with not less than 10mm crown.

35.19.3 Roof slope

35.19.3.1 Roof slopes

The roof slopes on which roof covering may be applied shall conform to Table 35.19.3A

35.19.4 Flashing at interclauses

35.19.4.1 Sheet metal flashing shall consist of not less than 1.70mm thick sheet lead, 0.33mm galvanized steel, 0.36mm thick copper, 0.46mm thick zinc or 0.48mm thick aluminium.

35.19.4.2 Valley flashing

Where sloping surfaces or shingled roofs intersect to form a valley, the valley shall be flashed.

35.19.4.3 Open valley flashing

Open valleys shall be flashed with not less than one layer of sheet metal not less than 600mm wide.

Table 35.19.3A

(Forming part of Article 35.19.3.1)

Roofing types and slope limits of roofs

<table>
<thead>
<tr>
<th>Type of Roofing</th>
<th>Minimum Slope</th>
<th>Maximum Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Built-up Roofing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt base (gravelled)</td>
<td>0 in 25</td>
<td>20 in 100</td>
</tr>
<tr>
<td>Asphalt base (without gravel Coal-tar base (gravelled)</td>
<td>1 in 25</td>
<td>50 in 100</td>
</tr>
<tr>
<td>25 in 100</td>
<td>25 in 75</td>
<td>no limit</td>
</tr>
<tr>
<td>25 in 100</td>
<td>0 in 25</td>
<td>no limit</td>
</tr>
<tr>
<td>25 in 100</td>
<td>25 in 500</td>
<td>no limit</td>
</tr>
<tr>
<td>Wood Shingles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handsplit shakes</td>
<td></td>
<td>no limit</td>
</tr>
<tr>
<td>Cement pulp asbestos corrugated sheets</td>
<td>50 in 100</td>
<td>no limit</td>
</tr>
<tr>
<td>Sheets metal roofing corrugated metal roofing Slate shingles Clay tile Glass fibre reinforced Polyester roofing panels</td>
<td>25 in 100</td>
<td>no limit</td>
</tr>
</tbody>
</table>
35.19.4.4 Closed valley flashing
Closed valley flashing shall consist of sheet metal not less than 600mm wide. Nails shall not penetrate the flashing within 75m of the top of the valley or 125mm of the bottom of the valley measured from the centerline of the valley.

35.19.4.5 Interclause flashing
The interclause of shingle roofs and masonry walls or chimneys shall be protected with flashing. Counter flashing embedded not less than 25mm in the masonry shall extend not less than 150mm down the masonry and lap the lower flashing not less than 100mm. Flashing along the slopes of a roof shall be stepped so that there is not less than 75mm head lap in both the lower flashing and counter flashing. Where the roof slopes upwards from the masonry, the flashing shall extend up the roof slope to a point equal in height to the flashing on the masonry, but not less than 1½ times the shingle exposure.

35.19.5 Wood roof shingles

35.19.5.1 Decking
Decking for wood shingled roofs may be continuous or spaced.

35.19.5.2 Size
Wood shingles shall be not less than 400mm long and less than 75mm nor more than 350mm wide.

35.19.5.3 Spacing
Shingles shall be spaced approximately 6mm apart and offset at the joints in adjacent courses not less than 40mm so that joints in alternate courses are staggered.

35.19.5.4 Fastening
Shingles shall be fastened with at least two (2) nails or staples located approximately 20mm from the sides of the shingles and 40mm above the exposure line.

35.19.5.5 Exposure
The exposure of wood roof shingles shall conform to Table 35.19.5A

<table>
<thead>
<tr>
<th>Roof Slope</th>
<th>Maximum Shingle Exposure, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>410mm Shingles</td>
</tr>
<tr>
<td>25 in 75 or</td>
<td>95</td>
</tr>
</tbody>
</table>

35.19.5.6 Flashing
Flashing shall conform to this Code.

35.19.6 Handsplit roof shakes

35.19.6.1 Size of shakes
Shakes shall be not less than 450mm long and less than 100mm not more than 350mm wide with a butt thickness of not more than 30mm.

35.19.6.2 Spacing of shakes
Shakes shall be spaced approximately 6mm apart and offset at the joints in adjacent courses not less than 40mm so that joints in alternate courses are staggered.

35.19.6.3 Fastening of shakes
Shakes shall be fastened with nails located approximately 20mm from the side of the shakes and 40mm above the exposure line.

35.19.6.4 Exposure of shakes
The exposure of wood shakes shall conform to Table 35.19.6A

<table>
<thead>
<tr>
<th>Minimum length of shakes (mm)</th>
<th>Limiting minimum butt thickness, (mm)</th>
<th>Maximum exposure, (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>10</td>
<td>190</td>
</tr>
<tr>
<td>300</td>
<td>10</td>
<td>250</td>
</tr>
<tr>
<td>800</td>
<td>10</td>
<td>330</td>
</tr>
</tbody>
</table>

35.19.6.5 Flashing
Flashing shall conform to Subclause 35.19.4

35.20 INTERIOR WALL AND CEILING FINISHES

35.20.1 General

35.20.1.1 The requirements for wall and ceiling finishes in this clause are basic requirements. Where a wall or ceiling
assembly is required to provide a certain fire-resistance, a flame-spread rating or a sound transmission class rating, the wall or ceiling finishing shall be subject to the appropriate requirements in this Code.

35.20.2 Waterproof wall finish

35.20.2.1 Waterproofing of interior finishes

Waterproof finish shall be provided to a height of not less than 1.8m above the floor in shower stalls, 1.2m above the rims of bathtubs equipped with showers and 400mm above the rims of bathtubs not equipped with showers.

35.20.2.2 Waterproof finish

Waterproof finish shall consist of granite, marble, ceramic, plastic or metal tile, sheet vinyl or linoleum etc.

35.20.3 Plywood finish

35.20.3.1 Plywood finish thickness

The minimum thickness of plywood interior finish shall conform to Table 35.20.3A except that no minimum thickness is required when the plywood is applied over solid backing.

<table>
<thead>
<tr>
<th>Minimum spacing of supports, mm, centres</th>
<th>On supports with no horizontal blocking, mm</th>
<th>On supports with blocking at vertical intervals not exceeding 1.2m, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>4.7</td>
<td>4.0</td>
</tr>
<tr>
<td>600</td>
<td>9.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>

35.20.3.2 Where plywood for interior finish is grooved, the grooves shall not extend through the face ply and into the plies below the face ply unless the groove is supported by framing or furring, or if the grain of the face ply is at right angles to supporting members, unless the thickness of the plywood exceeds the value shown in Table 35.20.3A by an amount equal to at least the depth of penetration of the grooves into the plies below the face ply.

35.20.3.3 Nails for plywood finish

Nails for attaching plywood finishes shall be not less than 38mm casing or finishing nails spaced not more than 150mm centres along edge supports and 300mm centres along intermediate supports, except that staples providing equivalent lateral resistance may also be used.

35.20.3.4 All plywood edges shall be supported by furring, blocking or framing.

35.20.4 Wall tile

35.20.4.1 Wall tile base and adhesive

Ceramic tile shall be set in a mortar base or applied with adhesive. Plastic tile shall be applied with an adhesive.

35.20.4.2 Mortar for ceramic tile

When ceramic tile is applied to a mortar base the cementitious material shall consist of one part Portland cement to not more than ¼ part of lime or clay pozzolana by volume. This shall be mixed with not less than three nor more than five parts of sand per part of cementitious material by volume. Ceramic tile applied to a mortar base shall be thoroughly soaked and pressed into place forcing the mortar into the joints while the tile is wet.

35.20.4.3 Adhesive for ceramic tile

Adhesives to attach ceramic or plastic tile shall be applied to the finish coat or brown coat of plaster that has been steel-trowelled to an even surface or to masonry provided the masonry has an even surface.

35.21 FLOORING

35.21.1 General

35.21.1.1 Finished flooring shall be provided in all residential occupancies.

35.21.1.2 Finished flooring materials

Finished flooring in bathrooms, kitchens, public entrance halls, laundry and general storage areas shall consist of resilient flooring, concrete, terrazzo, ceramic or other types of flooring providing similar degrees of water resistance.

35.21.1.3 Wood sleeper

Wood sleepers supporting finished flooring over a concrete base on ground shall be not less than 25mm by 50mm and shall be treated with a soaking coat of approved wood preservative.

35.21.1.4 Finished flooring shall have a surface that is smooth, even and free from roughness or open defects.
35.21.2 Wood strip flooring

35.21.2.1 Dimensions

The thickness of wood strip flooring shall conform to Table 35.21.2A

<table>
<thead>
<tr>
<th>Type of Flooring</th>
<th>Maximum Joist Spacing, mm</th>
<th>Minimum Actual Thickness of Flooring, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With Sub-floor</td>
</tr>
<tr>
<td>Hardwood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>/Exterior Use</td>
<td>600</td>
<td>20</td>
</tr>
</tbody>
</table>

35.21.2.2 Underlay

Wood strip flooring shall not be laid parallel to lumber sub-flooring unless a separate underlay is provided.

35.21.2.3 Laying of wood strip flooring

If wood strip flooring is applied without a subfloor, it shall be laid at right angles to the joists so that end joists are staggered and occur over supports or are end matched. It shall be laid so that no two adjoining strips break joints in the same space between supports and each strip bears on no fewer than two supports.

35.21.2.4 Nailing

Wood strip flooring shall be toe nailed or face nailed with at least 1 nail per strip at spacings shown in Table 35.21.2B except that face nailed strips of more than 25mm in width shall have no fewer than two nails per strip. Face nails shall be countersunk and the holes filled with suitable filler.

35.21.3 Parquet flooring

35.21.3.1 Adhesive used to attach parquet block flooring shall be suitable for bonding wood to the applicable subfloor material.

35.21.4 Ceramic tile

35.21.4.1 Ceramic tile shall be set in a mortar bed or applied to a sound smooth base with a suitable adhesive.

35.22 PLUMBING FACILITIES

35.22.1 Scope

35.22.1.1 This clause applies to the facilities required in plumbing systems within dwelling units. Plumbing and plumbing systems will generally conform to this Code.

35.22.1.2 Facilities in plumbing systems other than those required in dwelling units shall conform to Part 3 of this Code.

35.22.2 Water supply and distribution

35.22.2.1 Portable water

Every dwelling unit shall be supplied with portable water from an approved public or community system when these systems are available.

35.22.2.2 Piping facilities

Where a piped water supply is available, piping for cold water shall be connected to every kitchen sink, bathtub, shower and laundry area. Piping for cold water shall be run to every water closet and hose bib.

35.22.3 Required facilities

35.22.3.1 A kitchen sink, lavatory bathtub and water closet shall be provided for every dwelling unit where a piped water supply is available. Where there is not piped water...
supply other approved means of waste disposal shall be provided for every dwelling unit.

35.22.4 Sewage disposal

35.22.4.1 Except as provided in Article 35.22.3.1 wastes from every plumbing fixture shall be piped to the building sewer.

35.22.4.2 Building sewers shall discharge into a public sewage system where such system is available.

35.22.4.3 Where a public sewage system is not available, the building sewer shall discharge into a private sewage disposal system such as a septic tank and disposal field provided the design and installation is approved.

35.23 VENTILATION

35.23.1 Scope

35.23.1.1 This clause applies to the ventilation of rooms and spaces in residential occupancies but does not apply to the ventilations of rooms intended to be used for the lawful detention of any person other than a mentally disordered person.

35.23.1.2 Ventilation of rooms and spaces other than residential occupancies shall be in accordance with approved engineering practice.

35.23.1.3 A garage for parking more than five cars shall be ventilated in accordance with this Code.

35.23.2 Natural ventilation

35.23.2.1 Except as provided in Article 35.23.2.3 any habitable room shall (unless it is adequately ventilated by mechanical means) have one or more ventilation openings so constructed that:

i. their total area is equal to not less than 15% of the floor area of the room; and

ii. some part of such area is not less than 1.75m above the floor.

35.23.2.2 A door which opens directly to the external air shall be deemed to be a ventilation opening if:

i. such door contains a ventilator with an area of not less than 10,000mm² capable of being opened (without the door being opened); or

ii. the room contains one or more ventilation openings having a total area of not less than 10,000mm²; in addition to such door.

35.23.2.3 A habitable room opening into an enclosed verandah, conservatory or similar place shall be deemed to comply with the provisions of this regulation if such room and such enclosed place together have one or more ventilation openings which, if they ventilated a room having a floor area equal to the combined floor areas of such habitable room and such enclosed space would comply with the requirements of Article 35.23.2.1.

35.23.3 Ventilation openings onto courts

35.23.3.1 No ventilation opening constructed in compliance with subclause 35.23.2 shall be so situated as to open on to a court enclosed on every side, unless the distance from the ventilation opening to the opposite wall of the court is either:

i. 15m or more; or

ii. not less than ½ the vertical distance between the top of the wall containing the opening.

35.23.3.2 No ventilation opening constructed in compliance with requirements of Subclause 35.23.2 shall be so situated as to open onto a court which has one unobstructed side, exceeds twice the width, unless such ventilation opening:

i. is in the side of the court opposite the unobstructed side; or

ii. (if it is situated in either of the long sides) is within a distance from the unobstructed side not exceeding twice the width of the court; or

iii. (if it is situated in either of the long sides) is in such a position that the distance from such opening to the opposite wall of the court is either 15m or more; or not less than the vertical distance between the top of such opening and the top of the wall containing the opening.
35.23.4 Ventilation of larders

35.23.4.1 Any larder for the storage of perishable food (other than an enclosed space having means of refrigeration) shall, unless adequately ventilated by mechanical means be ventilated to the external air by means of one or more windows or two or more ventilations capable of being closed of which one is in the upper part and another in the lower part of the larder.

35.23.4.2 Windows used for the ventilation of larders shall be fitted with durable fly-proof screen and be so constructed that a total area of not less than 85,000mm$^2$ is capable of being opened.

35.23.4.3 Ventilators used for the ventilation of larders shall be:

i. fitted with a durable fly-proof screen; and

ii. so constructed as to permit (when open) the passage of air through an opening having an unobstructed area of not less than 45,000mm$^2$; and

iii. either situated in an external wall of the building or separately connected with the external air by a duct not less than 16,000mm$^2$ in cross-clausal area and having a smooth internal surface.

35.23.5 Ventilation of common stairways

35.23.5.1 Any part of a stairway which is intended for common use within any building constructed for occupation as separate dwellings by more than one family and above the ground storey and not open to the external air shall have adequate means of ventilation.

35.24 ELECTRICAL FACILITIES

35.24.1 General

35.24.1.1 Electrical installations, including the service capacity of the installation and the number and distribution of circuits shall meet the requirements of the appropriate local government statutes. Guidance for electrical installations are given in Part 9.2 of this Code.

35.24.1.2 Unless otherwise approved, electrical facilities shall be provided for every building and every dwelling unit and public shared space in building containing dwelling units.

35.24.1.3 Electrical facilities shall have sufficient capacity to provide, without overloading, electrical energy for lighting appliances, outlets and equipment installed in the building.

35.24.1.4 Entrance switches, meters, panel boxes, time clocks and other similar equipment shall not be located in any public area unless adequate precautions are taken to prevent interference with the equipment.

35.24.2 Lighting outlets

35.24.2.1 Exterior lighting
An exterior lighting outlet with fixture controlled by a wall switch located within the building shall be provided at every entrance to buildings of residential occupancy.

35.24.2.2 Requirements for lighting outlets
Except as provided in Article 35.24.2.3 a lighting outlet with fixture controlled by a wall switch shall be provided in kitchens, bedrooms, living rooms, utility rooms, dining rooms, bathrooms, water closet rooms, vestibules and hallways in dwelling units.

35.24.2.3 Where a receptacle controlled by a wall switch is provided in bedrooms or living rooms, such room need not conform to the requirements in Article 35.24.2.

35.24.2.4 Lights in stairways
Every stairway shall be lighted. Wall switches located at head and foot of every stairway shall be provided to control at least one lighting outlet with fixture for stairways with four or more risers in dwelling units.

35.24.2.5 Storage room
A lighting outlet with fixture shall be provided in storage rooms.

35.24.2.6 Lighting of garages and carports
A lighting outlet with fixture shall be provided for an attached, built-in or detached garage or carport. Such outlet shall be controlled by a wall switch near the doorway where the fixture is ceiling mounted above an area normally occupied by a parked car. Where a carport is lighted by a light at the entrance to a dwelling unit, additional carport lighting is not required.
35.24.2.7 Lighting in public areas

Every public or service area in buildings shall be provided with lighting outlets with fixtures controlled by a wall switch or panel to illuminate every portion of such areas.
PART 36: EXISTING BUILDINGS

The requirements of this Code shall apply to alterations, extensions, renovations including changes to use and occupancy to existing buildings.
PART 37: GREEN BUILDING REQUIREMENTS

37.1 Scope

This part of the Code applies to the following:
- Private Office and Commercial/Industrial buildings throughout Ghana that are above 5,000 m² total gross floor area;
- Public buildings located in all the Regional and District Capitals—that are above 500 m² in total gross floor area;
- Residential buildings throughout Ghana that are above 75 m².

Note: After 3 years the gross floor area limit shall be revised, based on the outcome of implementation.

The following Clauses describe the prescriptive and alternative compliance path with green building principles.

Note: All projects within the defined scope must comply either with option 1 (prescriptive compliance path) or with option 2 (alternative compliance path) to obtain the building permit.

37.2 DEFINITIONS

BUILDING RESEARCH ESTABLISHMENT ENVIRONMENTAL ASSESSMENT METHOD (BREEAM): A green certification system developed by Building Research Establishment of U.K.

COEFFICIENT OF PERFORMANCE (COP) - COOLING: The ratio of the rate of heat removal to the rate of energy input in consistent units, for a complete refrigeration system or some specific portion of that system under designated operating conditions.

DEUTSCHE GESELLSCHAFT FUR NACHHALTIGES BAUEN (DGNB): A green certification system developed by German Sustainable Building Council.

EXCELLENCE IN DESIGN FOR GREATER EFFICIENCY (EDGE): A green certification system developed by International Finance Corporation (IFC).

GREEN STAR: A green certification system developed by Green Building Council of Australia (GBCA).

LEADERSHIP IN ENVIRONMENTAL AND ENERGY DESIGN (LEED): A green certification system developed by U.S Green Building Council.

SOLAR HEAT GAIN COEFFICIENT (SHGC): It is the amount of heat admitted through the glass compared to the total heat incident on the glass by direct solar radiation. The unit is a simple fraction or percentage.

37.3 PRESCRIPTIVE COMPLIANCE PATH

37.3.1 Energy Efficiency Requirements

Achieving high energy efficiency in buildings starts with the three (3) Passive Design Strategies namely: Passive Ventilation, Passive Cooling and Daylighting.

37.3.1.1 Building Envelope Properties

Building envelope consists of walls, windows and the roof. An efficient building envelope is the most important and the primary step in increasing the energy efficiency of a building. The most important parameters of the building that needed to be controlled are as follows:

37.3.1.1.1 Window to Wall Ratio (WWR):

This is the ratio of the area of the window or other glazing area to the area of the gross exterior wall area of the building. The gross wall area will include all openings like doors and windows measured horizontally from one surface to the other and measured vertically from top of the floor to the top of the roof.

37.3.1.1.2 Solar Heat Gain Co-efficient (SHGC) of the Glazing:

Thermal transmission for glazing material is measured in terms of U-value for conduction and Solar Heat Gain Coefficient (SHGC) or Shading Coefficient (SC) for solar radiation.

Note: SHGC = 0.86 SC.

37.3.1.1.3 Exterior Shading:

The geometry of the shading devices must be designed in response to the sun path, which leads to different shapes and sizes for different orientations.

The requirements are based on the logic that the amount of solar radiation entering through windows should be kept at a defined maximum level. This maximum level was determined to be equivalent to the amount of radiation coming through clear glass (SHGC = 0.8) in a building with 30% WWR. So, if the building-
wide WWR is increased beyond 30%, a lower
SHGC glass should be used to maintain the
same amount of solar radiation coming into the
building.

Table 1: Maximum Unshaded Glass Solar Heat Gain Coefficient for different WWR

<table>
<thead>
<tr>
<th>Window to Wall ratio (WWR)</th>
<th>&lt;20%</th>
<th>21-40%</th>
<th>41-60%</th>
<th>61-80%</th>
<th>&gt;80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Unshaded Glass Solar Heat Gain Coefficient (USHGC)</td>
<td>0.80</td>
<td>0.60</td>
<td>0.48</td>
<td>0.40</td>
<td>0.34</td>
</tr>
</tbody>
</table>

If there is permanent exterior shading provided, these Unshaded Glass SHGC (USHGC) requirements can be relaxed. The following adjustment factors can be used:

Table 2: External Shading Adjustment Factors for glass SHGC

<table>
<thead>
<tr>
<th>DwH</th>
<th>-0.25</th>
<th>0.25-0.32</th>
<th>0.33-0.49</th>
<th>0.50-0.99</th>
<th>&gt;1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Shading Adjustment Factor (HAF)</td>
<td>0</td>
<td>0.31</td>
<td>0.36</td>
<td>0.43</td>
<td>0.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DwW</th>
<th>-0.25</th>
<th>0.25-0.32</th>
<th>0.33-0.49</th>
<th>0.50-0.99</th>
<th>&gt;1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Shading Adjustment Factor (VAF)</td>
<td>0</td>
<td>0.14</td>
<td>0.16</td>
<td>0.18</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Maximum Allowed SHGC = USHGC X [1+(HAF+VAF)]

**Note:** The above shading adjustment factors have been calculated for Accra weather using the EDGE Annual Average Shading Factor (AASF) calculation methodology. The shading factors were calculated for different orientations; however, it was found that the difference in resultant SHGC requirements for different orientations was less than 5%. Therefore, the same adjustment factors have been used for all orientations.

An example for this calculation is shown below:

**WWR, Window to Wall Ratio (from drawings): 67%**

**USHGC, Unshaded Solar Heat Gain Coefficient (from table 1 above) : 0.34**

**Horizontal Shading:**
- \( D_h \), Depth of horizontal overhang (area weighted average): 1 m
- \( H \), Glass height (area weighted average): 2 m
- \( D_r/H \), 0.5

**HAF, Horizontal Shading Factor (from table 2 above): 0.43**

**Vertical Shading:**
- \( D_v \), Depth of vertical overhang (area weighted average): 0.3 m
- \( W \), Glass width (area weighted average): 2.5 m
- \( D_r/W \), 0.12

**VAF, Vertical Shading Factor (from table 2 above): 0**

**Maximum Allowed Glass Solar Heat Gain Coefficient:**

\[
\text{USHGC X}(1+\text{HAF+VAF}) = 0.34(1+0.43+0) = 0.49
\]
The efficiency (COP) recommendations are based on the size of the cooling system, as bigger systems typically are available with higher efficiencies.

The cooling system efficiency must meet or exceed the minimum efficiency requirement according as listed in Table below.

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Cooling power, kW</th>
<th>COPmin kW/kW</th>
<th>EER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaged terminal air conditioner</td>
<td>-</td>
<td>2.8</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>&lt; 4.5 kW</td>
<td>3.1</td>
<td>10.6</td>
</tr>
<tr>
<td>Split-system air conditioner</td>
<td>≥ 4.5 kW and &lt; 7.0 kW</td>
<td>3</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td>≥ 7.0 kW and &lt; 14.0 kW</td>
<td>2.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Air-cooled air conditioner</td>
<td>≥ 14 kW and &lt; 19 kW</td>
<td>3.81</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>≥ 19 kW and &lt; 40 kW</td>
<td>3.28</td>
<td>11.2</td>
</tr>
<tr>
<td></td>
<td>≥ 40 kW and &lt; 70 kW</td>
<td>3.22</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>≥ 70 kW and &lt; 223 kW</td>
<td>2.93</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>≥ 223 kW</td>
<td>2.84</td>
<td>9.7</td>
</tr>
</tbody>
</table>
### Table 2: Minimum efficiencies requirements for chillers

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Cooling power, kW</th>
<th>COP&lt;sub&gt;mea&lt;/sub&gt; kW/kW</th>
<th>EER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-cooled chiller, electric Attached or split condenser</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>2.8</td>
<td></td>
<td>9.6</td>
</tr>
<tr>
<td>&lt; 264 kW</td>
<td>4.51</td>
<td></td>
<td>15.4</td>
</tr>
<tr>
<td>≥ 264 and &lt; 528 kW</td>
<td>4.53</td>
<td></td>
<td>15.5</td>
</tr>
<tr>
<td>≥ 528 and &lt; 1055 kW</td>
<td>5.17</td>
<td></td>
<td>17.6</td>
</tr>
<tr>
<td>≥ 1055 kW</td>
<td>5.67</td>
<td></td>
<td>19.3</td>
</tr>
<tr>
<td>&lt; 528 kW</td>
<td>5.55</td>
<td></td>
<td>18.9</td>
</tr>
<tr>
<td>≥ 528 and &lt; 1055 kW</td>
<td>5.55</td>
<td></td>
<td>18.9</td>
</tr>
<tr>
<td>≥ 1055 and &lt; 2110 kW</td>
<td>6.11</td>
<td></td>
<td>20.8</td>
</tr>
<tr>
<td>≥ 2110 kW</td>
<td>6.17</td>
<td></td>
<td>21.1</td>
</tr>
<tr>
<td>Air-cooled absorber chiller, single effect *</td>
<td>All</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Absorption water-cooled chiller, double effect*</td>
<td>All</td>
<td>0.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Absorber chiller, double effect, indirect burn*</td>
<td>All</td>
<td>1.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Absorber chiller, double effect, directly burn*</td>
<td>All</td>
<td>1.0</td>
<td>3.4</td>
</tr>
</tbody>
</table>

**Notes:**

(*) For absorber chillers, COP = Cooling power/Input power. Performance rating for absorber chillers uses ARI 560 standards. Performance rating for water-cooling units is subject to ARI 550/590.

### Applicability:

Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools

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#### 37.4.2 Variable Speed Drives

Variable Speed Drive (VSD) control the speed of machinery by changing the frequency of the motor operating it. Where process conditions demand adjustment of flow from a pump or fan, varying the speed of the drive save energy as compared to constant speed drives.

**Notes:**

a. Cooling towers and closed-circuit fluid coolers: must have variable speed drives for controlling the fans.
b. Hydronic System Design and Control: HVAC hydronic systems having a total pump system power exceeding 7.5 kW must use variable speed drives.
c. Air handling units: The air handling units, which are more than 7.5 kW, must use variable speed drives with variable air volumes boxes.
d. Exemptions: Kitchen ventilation fans are exempt from the above rule.

In addition, all the equipment such as pumps and fans must use only high efficiency motors.

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### 37.5 LIGHTING AND ELECTRICAL POWER

#### 37.5.1 Lighting control system

Building perimeter zones exposed to daylight generally do not require artificial lighting during the day. However, sub-optimal design and operation of the building results in use of artificial lighting when not required.

Buildings with good daylight access improve indoor ambience. Energy savings are only available if the lights are switched off or dimmed. This could be done manually. Higher energy saving is possible by using strategically placed photoelectric sensors in the space.
Lights in following areas must have photo sensor control, if they are on the perimeter, bigger than 50m² in area, and have exterior windows:

1. Offices - open offices, lobby, meeting rooms
2. Retail Buildings -
3. Hotels - meeting rooms
4. Schools - meeting rooms/auditorium

Lights in following areas must have occupancy sensor control:
1. Offices - meeting rooms, staircases, enclosed office spaces, and corridors
2. Hotels - meeting rooms and corridors
3. Residential Buildings - enclosed car parks, staircases and corridors
4. Schools - enclosed car parks, classroom and corridors

If occupancy sensors are installed in the daylight area, the occupancy sensor must override the daylight sensor during non-occupancy period. Emergency/exit lighting are not required to have occupancy sensor controls.

37.5.2 Energy efficient lighting system

Lighting accounts for a substantial portion of a typical household’s energy bill. Cutting lighting bill is one of the easiest ways to save energy and money.

Requirements:
Interior electric lighting in all building types given shall not exceed the maximum installed lighting presented in the table below. This maximum LPD values apply for general lighting installation and do not include task lighting and display lighting.

Note:

Table 5: Maximum Lighting Power Densities (LPD)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>LPD (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>11</td>
</tr>
<tr>
<td>Hotel</td>
<td>11</td>
</tr>
<tr>
<td>Hospital</td>
<td>13</td>
</tr>
<tr>
<td>Health care center</td>
<td>11</td>
</tr>
<tr>
<td>Library</td>
<td>14</td>
</tr>
<tr>
<td>Convention</td>
<td>15</td>
</tr>
<tr>
<td>School</td>
<td>12</td>
</tr>
<tr>
<td>Commercial, services</td>
<td>16</td>
</tr>
<tr>
<td>Indoor parking space</td>
<td>3</td>
</tr>
</tbody>
</table>

Notes:
- The Lighting power density – LPD, is determined by the total design lighting load divided by the serviced gross floor area.
- In a mixed-purpose (complex) building, LPD shall be determined using the lighting load and the floor area for each purpose.
- For areas or parts with special lighting needs in educational, health care facilities or others, the Lighting power density – LPD adopted shall be the applicable designed values.

LPD for car parks is the total lighting power divided by the total car park area. In the mixed used buildings, each building type area must comply with the LPD of corresponding building type.

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Schools

37.5.3 Residential Energy efficient lighting system

Requirements:
For residential buildings, one of these lamp types must be used in the lighting system:

1. Fluorescent Lamps – Size T5 with electronic ballast
2. Compact Fluorescent Lamps
3. LED (Light Emitting Diode) Lamps

Applicability: Residential Buildings
37.6 WATER EFFICIENCY

37.6.1 Water efficient fittings

Water efficient fittings are fittings like faucets, shower heads and flushes that use less water to perform the same function of cleaning as effectively as some of the older outdated models of fittings.

Recommendation:
The following table shows the requirement maximum flow rate or flush capacity.

<table>
<thead>
<tr>
<th>Type of Fixture</th>
<th>Maximum allowed gallons</th>
<th>Maximum allowed liters</th>
<th>Units/ conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Showerhead</td>
<td>2.1</td>
<td>8.0</td>
<td>per minute at 417.7 kPa (60PSi)</td>
</tr>
<tr>
<td>Toilet Faucet</td>
<td>1.6</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Kitchen Faucet</td>
<td>1.8</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Water closet (single flush)</td>
<td>1.3</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Water closet (double flush)</td>
<td>1.6 (1st), 0.8(2nd)</td>
<td>6.0 (1st), 3.0(2nd)</td>
<td></td>
</tr>
<tr>
<td>Urinal</td>
<td>0.5</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Please note that lower flow rates in faucets are possible by fitting them with aerators/ flow restrictors.

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools

37.6.2 Rain-water harvesting

Rainwater is one of the purest sources of water available. Accra on an average gets about 787 mm of rainfall annually which is equivalent to 787,000 m³/m² of collection area. This highlights the potential of water saving through rain water harvesting.

The rule of thumb [15 liters per m² of roof collection area] can be used for calculating rainwater collection tank size that would be big enough to store an average week’s rainfall.

For example, the following tank sizing is done to collect at least 50% of the rain falling on the roof in one week. Using this calculation, desired tank capacity is 749 liters.

37.6.3 Stormwater Management

37.6.3.1 Metering of Groundwater consumption

Requirement:
At least 50% of the roof area to be used for diversion of rainwater to a dedicated storage tank OR to the raw water tank.

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools

37.6.3.2 Storage tank sizing

Requirements:

| A | Accra Annual rainfall (mm) | 787 |
| B | average weekly rainfall (mm) | 15.1 |
| C | plan roof area (m²) | 100.0 |
| D | % roof area available | 50% |
| E | Conversion Factor | 0.99 |
|   | tank size (liters) = A*B*C*D*E | 749 |
|   | Tank size (liters/m² of collection area) | 15.0 |

Source: http://www.acora.climatemps.com/ https://rainwaterharvesting.tamu.edu/catchment-area/

Requirement:
All groundwater wells used for consumption in the building must have a consumption meter installed.

Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools
37.6.3.2 Minimum Open Unpaved Area
 Requirement:
50% of all unbuilt area on the site must be left unpaved, i.e. having grass or ground.
Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings
37.6.3.3 Permeable Paving for Parking
 Requirement:
50% of all exterior hardscape (excluding roads) must have permeable paving, i.e. allowing water to percolate through and absorbed in the ground.
Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential Buildings, Schools.

37.7 WASTEWATER MANAGEMENT
37.7.1 Sewage Treatment Plant
 Requirement:
Sewage Treatment Plant must be provided for all buildings 1500 m2 or above, or 15 homes and above for multi-family residential. The Treated water must be used for irrigation, cooling towers or flushing.
Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential (Apartments and Gated Communities), Schools

37.7.2 Solid Waste Management
37.7.2.1 Waste Collection and Segregation
 Facility
 Requirement:
All buildings must have an enclosed waste collection and segregation facility that is at least 1 m2 per 250 m2 gross floor area.
Applicability: Offices, Retail Buildings, Hotels, Hospitals, Residential (Apartment), Schools

37.8 INDOOR ENVIRONMENTAL QUALITY
37.8.1 CO2 Control of Outside Air
 Requirement:
Carbon Dioxide sensors must be installed in return air ducts of all auditoriums and large conference rooms and theatres larger than 200 m2 to maintain the CO2 concentration below 1000 ppm.
Applicability: Offices, Retail Buildings, Hotels, Hospitals, School

37.8.2 CO Control of Garage Ventilation
 Requirement:
Carbon Monoxide sensors must be installed to automatically turn on ventilation fans for enclosed garage with more than 20 car parking slots.
Applicability: Offices, Retail Buildings, Hotels, Hospitals, Schools

37.9 SOLAR PHOTOVOLTAIC (PV)
Installation of solar PV shall cover the following:
- Private Office and Commercial/Industrial buildings throughout Ghana that are above 5,000 m² total gross floor area;
- Public buildings located in all the Regional and District Capitals that are above 500 m² in total gross floor area;
- Residential buildings throughout Ghana that are above 75 m².

37.10 CERTIFICATION COMPLIANCE PATH
Buildings certified at design and construction stage with any of the international green building certification systems (EDGE, DGNB, LEED, BREEAM, Green Star or any other government approved rating system) shall be considered as a replacement to all prescriptive requirements of this Code.

Project owners must submit the design certificate for one of the above-mentioned certification systems to be eligible to receive the Building Permit.

To get the Certificate of Habitation, the project owner needs to provide either the final certificate from the above-mentioned systems, OR arrange for an accredited 3rd party inspector to conduct a site visit and issue a report of compliance with the respective certification requirements.
PART 38: REFERENCED STANDARDS

User note:
About this part: The Ghana Building Code contains numerous references to standards promulgated by other organizations that are used to provide requirements for materials and methods of construction. This part contains a comprehensive list of all standards that are referenced in this Code. These standards, in essence, are part of this Code to the extent of the reference to the standard.

This part lists the standards that are referenced in various clauses of this document. The standards are listed herein by the promulgating agency of the standard, the standard identification, the effective date and title, and the clause or clauses of this document that reference the standard. The application of the referenced standards shall be as specified in Clause 1.2.4.

<table>
<thead>
<tr>
<th>ACI</th>
<th>American Concrete Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>216.1—14: Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies</td>
<td></td>
</tr>
<tr>
<td>318—14: Building Code Requirements for Structural Concrete</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANSI</th>
<th>American National Standards Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>A13.1—2015: Scheme for the Identification of Piping Systems</td>
<td></td>
</tr>
<tr>
<td>A108.1A—16: Installation of Ceramic Tile in the Wet-set Method, with Portland Cement Mortar</td>
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<tr>
<td>A108.1B—99: Installation of Ceramic Tile, Quarry Tile on a Cured Portland Cement Mortar Setting Bed with Dry-set or Latex-Portland Mortar</td>
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</tr>
<tr>
<td>A108.4—99: Installation of Ceramic Tile with Organic Adhesives or Water-cleanable Tile-setting Epoxy Adhesive</td>
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<tr>
<td>A108.5—99: Installation of Ceramic Tile with Dry-set Portland Cement Mortar or Latex-Portland Cement Mortar</td>
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<tr>
<td>A108.6—99: Installation of Ceramic Tile with Chemical-resistant, Water Cleanable Tile-setting and -grouting Epoxy</td>
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<td>A108.8—99: Installation of Ceramic Tile with Chemical-resistant Furan Resin Mortar and Grout</td>
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<tr>
<td>A108.9—99: Installation of Ceramic Tile with Modified Epoxy Emulsion Mortar/Grout</td>
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</tr>
<tr>
<td>A108.10—99: Installation of Grout in Tilework</td>
<td></td>
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<tr>
<td>A118.1—16: American National Standard Specifications for Dry-set Portland Cement Mortar</td>
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<tr>
<td>A118.4—16: American National Standard Specifications for Modified Dry-set Cement Mortar</td>
<td></td>
</tr>
<tr>
<td>A118.5—99: American National Standard Specifications for Chemical Resistant Furan Mortar and Grouts for Tile Installation</td>
<td></td>
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<tr>
<td>A118.6—10: American National Standard Specifications for Cement Grouts for Tile Installation</td>
<td></td>
</tr>
<tr>
<td>A118.8—99: American National Standard Specifications for Modified Epoxy Emulsion Mortar/Grout</td>
<td></td>
</tr>
<tr>
<td>A136.1—08: American National Standard Specifications for the Installation of Ceramic Tile</td>
<td></td>
</tr>
<tr>
<td>A137.1—17: American National Standard Specifications for Ceramic Tile</td>
<td></td>
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<tr>
<td>Z 97.1—14: Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Test</td>
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<thead>
<tr>
<th>ASME</th>
<th>American Society of Mechanical Engineers</th>
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<tbody>
<tr>
<td>ASME/A17.1—2016/CSA B44—16: Safety</td>
<td></td>
</tr>
</tbody>
</table>

1277
Code for Elevators and Escalators


A18.1—2014: Safety Standard for Platform Lifts and Stairway Chairlifts

A90.1—2015: Safety Standard for Belt Manifolds

B16.18—2012: Cast Copper Alloy Solder Joint Pressure Fittings

B16.22—2013: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

B20.1—2015: Safety Standard for Conveyors and Related Equipment

B31.3—2016: Process Piping

<table>
<thead>
<tr>
<th>ASTM</th>
<th>ASTM International</th>
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</table>

A6/A6M—14: Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling

A36/A36M—14: Specification for Carbon Structural Steel

A153/A153M—09: Specification for Zinc Coating (Hot-dip) on Iron and Steel Hardware

A240/A240M—15a: Standard Specification for Chromium and Chromium-nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications

A252—10: Specification for Welded and Seamless Steel Pipe Piles

A283/A283M—13: Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

A416/A416M—15: Specification for Steel Strand, Uncoated Seven-wire for Prestressed Concrete

A463/A463M—15: Standard Specification for Steel Sheet, Aluminum-coated, by the Hot-dip Process

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A572/A572M—15: Specification for High-strength Low-alloy Columbium-Vanadium Structural Steel

A588/A588M—15: Specification for High-strength Low-alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point with Atmospheric Corrosion Resistance

A615/A615M—15ae1: Specification for Deformed and Plain Carbon-steel Bars for Concrete Reinforcement

A653/A653M—15: Specification for Steel Sheet, Zinc-coated Galvanized or Zinc-Iron Alloy-coated Galvannealed by the Hot-dip Process

A690/A690M—13a: Standard Specification for High-strength Low-alloy Nickel, Copper, Phosphorus Steel H-piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments

A706/A706M—15: Specification for Low-alloy Steel Deformed and Plain Bars for Concrete Reinforcement

A722/A722M—15: Specification for High-strength Steel Bars for Prestressed Concrete


A875/A875M—13: Standard Specification for Steel Sheet, Zinc-5%, Aluminum Alloy-coated by the Hot-dip Process

A924/A924M—14: Standard Specification for General Requirements for Steel Sheet, Metallic-coated by the Hot-dip Process

B42—2015A: Specification for Seamless Copper Pipe, Standard Sizes

B68/B68M—11: Specification for Seamless Copper Tube, Bright Annealed (Metric)

B88—14: Specification for Seamless Copper Water Tube

B101—12: Specification for Lead-coated Copper Sheet and Strip for Building Construction

B209—14: Specification for Aluminum and Aluminum Alloy Steel and Plate

B251—10: Specification for General Requirements for Wrought Seamless Copper and Copper-alloy Tube

B280—13: Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

B370—12: Specification for Copper Sheet and Strip for Building Construction


C5—10: Specification for Quicklime for Structural Purposes

C22/C22M—00(2015): Specification for Gypsum

C27—98(2013): Specification for Classification of Fireclay and High-alumina Refractory Brick


C31/C31M—15: Practice for Making and Curing Concrete Test Specimens in the Field

C33/C33M—13: Specification for Concrete Aggregates


C55—2014a: Specification for Concrete Building Brick

C59/C59M—00(2015): Specification for Gypsum Casting Plaster and Molding Plaster


C62—13a: Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)

C67—14: Test Methods of Sampling and Testing Brick and Structural Clay Tile

C73—14: Specification for Calcium Silicate Brick (Sand-lime Brick)

C90—14: Specification for Loadbearing Concrete Masonry Units

C91/C91M—12: Specification for Masonry Cement

C94/C94M—15a: Specification for Ready-mixed Concrete

C140/C140M—15: Test Method Sampling and Testing Concrete Masonry Units and Related Units

C150/C150M—15: Specification for Portland Cement

C172/C172M—14a: Practice for Sampling Freshly Mixed Concrete

C199—84(2011): Test Method for Pier Test for Refractory Mortars

C206—14: Specification for Finishing Hydrated Lime

C208—12: Specification for Cellulosic Fiber Insulating Board

C216—15: Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)

C270—14a: Specification for Mortar for Unit Masonry


C317/C317M—00(2015): Specification for Gypsum Concrete

C330/C330M—14: Specification for Lightweight Aggregates for Structural Concrete

C331/C331M—14: Specification for Lightweight Aggregates for Concrete Masonry Units
<table>
<thead>
<tr>
<th>Specification</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>C406/C406M—15</td>
<td>Specification for Roofing Slate</td>
</tr>
<tr>
<td>C473—15</td>
<td>Test Methods for Physical Testing of Gypsum Panel Products</td>
</tr>
<tr>
<td>C474—15</td>
<td>Test Methods for Joint Treatment Materials for Gypsum Board Construction</td>
</tr>
<tr>
<td>C475/C475M—15</td>
<td>Specification for Joint Compound and Joint Tape for Finishing Gypsum Board</td>
</tr>
<tr>
<td>C516—08(2014)e1</td>
<td>Specifications for Vermiculite Loose Fill Thermal Insulation</td>
</tr>
<tr>
<td>C547—15</td>
<td>Specification for Mineral Fiber Pipe Insulation</td>
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<tr>
<td>C549—06(2012)</td>
<td>Specification for Perlite Loose Fill Insulation</td>
</tr>
<tr>
<td>C552—15</td>
<td>Standard Specification for Cellular Glass Thermal Insulation</td>
</tr>
<tr>
<td>C557—03(2009)e01</td>
<td>Specification for Adhesives for Fastening Gypsum Wallboard to Wood Framing</td>
</tr>
<tr>
<td>C578—15</td>
<td>Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation</td>
</tr>
<tr>
<td>C595/C595M—14e1</td>
<td>Specification for Blended Hydraulic Cements</td>
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<tr>
<td>C635/C635M—13a</td>
<td>Specification for the Manufacture, Performance and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings</td>
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<tr>
<td>C636/C636M—13</td>
<td>Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels</td>
</tr>
<tr>
<td>C652—15</td>
<td>Specification for Hollow Brick (Hollow Masonry Units Made from Clay or Shale)</td>
</tr>
<tr>
<td>C726—12</td>
<td>Standard Specification for Mineral Wool Roof Insulation Board</td>
</tr>
<tr>
<td>C728—15</td>
<td>Standard Specification for Perlite Thermal Insulation Board</td>
</tr>
<tr>
<td>C744—14</td>
<td>Specification for Prefaced Concrete and Calcium Silicate Masonry Units</td>
</tr>
<tr>
<td>C754—15</td>
<td>Specification for Installation of Steel Framing Members to Receive Screw-attached Gypsum Panel Products</td>
</tr>
<tr>
<td>C836/C836M—15</td>
<td>Specification for High-solids Content, Cold Liquid-applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course</td>
</tr>
<tr>
<td>C840—13</td>
<td>Specification for Application and Finishing of Gypsum Board</td>
</tr>
<tr>
<td>C841—03(2013)</td>
<td>Specification for Installation of Interior Lathing and Furring</td>
</tr>
<tr>
<td>C844—2015</td>
<td>Specification for Application of Gypsum Base to Receive Gypsum Veneer Plaster</td>
</tr>
<tr>
<td>C847—14a</td>
<td>Specification for Metal Lath</td>
</tr>
<tr>
<td>C887—13</td>
<td>Specification for Packaged, Dry Combined Materials for Surface Bonding Mortar</td>
</tr>
<tr>
<td>C897—15</td>
<td>Specification for Aggregate for Job-mixed Portland Cement-based Plaster</td>
</tr>
<tr>
<td>C920—14a</td>
<td>Standard for Specification for Elastomeric Joint Sealants</td>
</tr>
<tr>
<td>C926—15b</td>
<td>Specification for Application of Portland Cement-based Plaster</td>
</tr>
<tr>
<td>C933—14</td>
<td>Specification for Welded Wire Lath</td>
</tr>
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</table>
C946—10: Specification for Construction of Dry-stacked, Surface-bonded Walls

C954—15: Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 inch (0.84 mm) to 0.112 inch (2.84 mm) in Thickness


C957/C957M—15: Specification for High-solids Content, Cold Liquid-applied Elastomeric Waterproofing Membrane with Integral Wearing Surface

C1002—14: Specification for Steel Self-piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

C1007—11a(2015): Specification for Installation of Load Bearing (Transverse and Axial) Steel Studs and Related Accessories

C1029—15: Specification for Spray-applied Rigid Cellular Polyurethane Thermal Insulation

C1032—14: Specification for Woven Wire Plaster Base

C1047—14a: Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base


C1088—14: Specification for Thin Veneer Brick Units Made from Clay or Shale


C1167—11: Specification for Clay Roof Tiles

C1177/C1177M—13: Specification for Glass Mat Gypsum Substrate for Use as Sheathing

C1178/C1178M—13: Specification for Coated Mat Water-resistant Gypsum Backing Panel


C1261—13: Specification for Firebox Brick for Residential Fireplaces


C1280—13a: Specification for Application of Exterior Gypsum Panel Products for Use as Sheathing

C1283—11: Practice for Installing Clay Flue Lining


C1325—14: Standard Specification for Nonasbestos Fiber-mat Reinforced Cement Backer Units

C1328/C1328M—12: Specification for Plastic (Stucco Cement)

C1364—10B: Standard Specification for Architectural Cast Stone

C1396/C1396M—14a: Specification for Gypsum Board


C1600/C1600M—11: Standard Specification for Rapid Hardening Hydraulic Cement

C1629/C1629M—15: Standard Classification for Abuse-resistant Nondecorated Interior Gypsum Panel Products and Fiber-reinforced Cement Panels
C1670—16: Standard Specification for Adhered Manufactured Stone Masonry Veneer Units
D25—12: Specification for Round Timber Piles
D41/D41M—11: Specification for Asphalt Primer Used in Roofing, Dampproofing and Waterproofing
D43/D43M—00(2012)e1: Specification for Coal Tar Primer Used in Roofing, Dampproofing and Waterproofing
D56—05(2010): Test Method for Flash Point by Tag Closed Cup Tester
D86—15: Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure
D93—15: Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D226/D226M—09: Specification for Asphalt-saturated Organic Felt Used in Roofing and Waterproofing
D227/D227M—03(2011)e1: Specification for Coal-tar-saturated Organic Felt Used in Roofing and Waterproofing
D312/D312M—15: Specification for Asphalt Used in Roofing
D422—63(2007)e2: Test Method for Particle-size Analysis of Soils
D448—2012: Standard Classification for Sizes of Aggregate for Road and Bridge Construction
D450/D450M—07(2013)e1: Specification for Coal-tar Pitch Used in Roofing, Dampproofing and Waterproofing
D635—14: Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
D1227—13: Specification for Emulsified Asphalt Used as a Protective Coating for Roofing
D1557—12e1: Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft-lb/ft3 (2,700 kN/m3)]
D1929—16: Standard Test Method for Determining Ignition Temperature of Plastics
D2178/D2178M—15: Specification for Asphalt Glass Felt Used in Roofing and Waterproofing
D2487—11: Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2822/D2822M—05(2011)e1: Specification for Asphalt Roof Cement, Asbestos Containing
D2823/D2823M—05(2011)e1: Specification for Asphalt Roof Coatings, Asbestos Containing
D2843—16: Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics
D3019—08: Specification for Lap Cement
Used with Asphalt Roll Roofing, Nonfibered, Asbestos Fibered and Nonasbestos Fibered

D3161/D3161M—15: Test Method for Wind Resistance of Steep Slope Roofing Products (Fan Induced Method)


D3278—96(2011): Test Methods for Flash Point of Liquids by Small Scale Closed-cup Apparatus

D3462/D3462M—10a: Specification for Asphalt Shingles Made from Glass Felt and Surfaced with Mineral Granules


D3679—13: Specification for Rigid Poly (Vinyl Chloride) (PVC) Siding


D3737—12: Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)


D3909/D3909M—14: Specification for Asphalt Roll Roofing (Glass Felt) Surfaced with Mineral Granules


D4318—10e1: Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils

D4434/D4434M—12: Specification for Poly (Vinyl Chloride) Sheet Roofing


D4637/D4637M—14e1: Specification for EPDM Sheet Used in Single-ply Roof Membrane

D4829—11: Test Method for Expansion Index of Soils


D4990—97a(2013): Specification for Coal Tar Glass Felt Used in Roofing and Waterproofing

D5019—07a: Specification for Reinforced Nonvulcanized Polymeric Sheet Used in Roofing Membrane

D5055—13e1: Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-joists

D5456—14b: Specification for Evaluation of Structural Composite Timber Products

D5516—09: Test Method of Evaluating the Flexural Properties of Fire-retardant Treated Softwood Plywood Exposed to Elevated Temperatures


D5665/D5665M—99a(2014)e1: Specification for Thermoplastic Fabrics Used in Cold-applied Roofing and Waterproofing

D5726—98(2013): Specification for Thermoplastic Fabrics Used in Hot-applied Roofing and Waterproofing

D6083—05e01: Specification for Liquid Applied Acrylic Coating Used in Roofing


D6464—03a(2009)e1: Standard Specification for Expandable Foam Adhesives for Fastening Gypsum Wallboard to Wood Framing


D6754/D6754M—10: Standard Specification for Ketone Ethylene Ester Based Sheet Roofing

D6841—08: Standard Practice for Calculating Design Value Treatment Adjustment Factors for Fire-retardant Treated Timber


(Uplift Force/Uplift Resistance Method)

D7254—15: Standard Specification for Polypropylene (PP) Siding


D7655/D7655M—12: Standard Classification for Size of Aggregate Used as Ballast for Roof Membrane Systems

D7672—14: Standard Specification for Evaluating Structural Capacities of Rim Board Products and Assemblies


E90—09: Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements


E136—16: Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C


E681—09(2015): Test Methods for Concentration Limits of Flammability of Chemical Vapours and Gases


E814—2013A: Test Method for Fire Tests of Penetration Firestop Systems


E1300—12ae1: Practice for Determining Load Resistance of Glass in Buildings


E1886—13A: Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Standard Name and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2072—14</td>
<td>Standard Specification for Photoluminescent (Phosphorescent) Safety Markings</td>
</tr>
<tr>
<td>E2174—14b</td>
<td>Standard Practice for On-site Inspection of Installed Fire Stops</td>
</tr>
<tr>
<td>E2178—13</td>
<td>Standard Test Method for Air Permeance of Building Materials</td>
</tr>
<tr>
<td>E2353—14</td>
<td>Standard Test Methods for Performance of Glazing in Permanent Railing Systems, Guards and Balustrades</td>
</tr>
<tr>
<td>E2404—15a</td>
<td>Practice for Specimen Preparation and Mounting of Textile, Paper or Polymeric (Including Vinyl) and Wall or Ceiling Coverings, Facing and Veneers to Assess Surface Burning Characteristics</td>
</tr>
<tr>
<td>E2556/E2556M—10</td>
<td>Standard Specification for Vapour Permeable Flexible Sheet Water-resistant Barriers Intended for Mechanical Attachment</td>
</tr>
<tr>
<td>E2568—09e1</td>
<td>Standard Specification for PB Exterior Insulation and Finish Systems</td>
</tr>
<tr>
<td>E2573—12</td>
<td>Standard Practice for Specimen Preparation and Mounting of Site-fabricated Stretch Systems to Assess Surface Burning Characteristics</td>
</tr>
<tr>
<td>E2579—13</td>
<td>Standard Practice for Specimen Preparation and Mounting of Wood Products to Assess Surface Burning Characteristics</td>
</tr>
<tr>
<td>E2599—15</td>
<td>Standard Practice for Specimen Preparation and Mounting of Reflective Insulation, Radiant Barrier and Vinyl Stretch Ceiling Materials for Building Applications to Assess Surface Burning Characteristics</td>
</tr>
<tr>
<td>E2751/E2751M—13</td>
<td>Practice for Design and Performance of Supported Laminated Glass Walkways</td>
</tr>
<tr>
<td>F1667—15</td>
<td>Specification for Driven Fasteners: Nails, Spikes and Staples</td>
</tr>
<tr>
<td>F2006—17</td>
<td>Standard/Safety Specification for Window Fall Prevention Devices for Nonemergency Escape (Egress) and Rescue (Ingress) Windows</td>
</tr>
<tr>
<td>F2090—17</td>
<td>Specification for Window Fall Prevention Devices with Emergency Escape (Egress) Release Mechanisms</td>
</tr>
<tr>
<td>F2200—14</td>
<td>Standard Specification for Automated Vehicular Gate Construction</td>
</tr>
<tr>
<td>G152—13</td>
<td>Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials</td>
</tr>
<tr>
<td>G154—12a</td>
<td>Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials</td>
</tr>
<tr>
<td>G155—13</td>
<td>Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials</td>
</tr>
<tr>
<td>Standard</td>
<td>Title</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>AWC WCD No. 4—2003: Wood Construction Data—Plank and Beam Framing for Residential Buildings</td>
<td></td>
</tr>
<tr>
<td>AWC STJR—2015: Span Tables for Joists and Rafters</td>
<td></td>
</tr>
<tr>
<td>ANSI/AWC PWF—2015: Permanent Wood Foundation Design Specification</td>
<td></td>
</tr>
<tr>
<td>ANSI/AWC SDPWS—2015: Special Design Provisions for Wind and Seismic</td>
<td></td>
</tr>
<tr>
<td>AWC</td>
<td>American Wood Council</td>
</tr>
<tr>
<td>AWCI</td>
<td>Association of the Wall and Ceiling Industry</td>
</tr>
<tr>
<td>AWPA</td>
<td>American Wood Protection Association</td>
</tr>
<tr>
<td>CEN</td>
<td>European Committee for Standardization (CEN)</td>
</tr>
<tr>
<td>BS 1305</td>
<td>Specification for batch type concrete mixers</td>
</tr>
<tr>
<td>BS EN 196–21</td>
<td>Fiber-cement Flat Sheets—Product Specification and Test Methods</td>
</tr>
<tr>
<td>BS EN 1744-1</td>
<td>Test for chemical properties of aggregates. Chemical analysis</td>
</tr>
<tr>
<td>BS EN 480-10</td>
<td>Admixtures for Concrete, mortar and grout. Test methods. Determination of water soluble chloride content</td>
</tr>
<tr>
<td>BS EN 196-21</td>
<td>Methods of testing cement. Determination of the chloride, carbon dioxide and alkali content of cement</td>
</tr>
<tr>
<td>BS EN 12390-3</td>
<td>Testing hardened concrete. Compressive strength of test specimens</td>
</tr>
<tr>
<td>BS 1305</td>
<td>Specification for batch type concrete mixers</td>
</tr>
<tr>
<td>BS EN 206</td>
<td>Concrete. Specification, performance, production and conformity</td>
</tr>
<tr>
<td>EN 310</td>
<td>D1.4/D1.4M—2017: Structural Welding Code—Reinforcing Steel Connections in Reinforced Concrete Construction</td>
</tr>
<tr>
<td>CEN</td>
<td></td>
</tr>
<tr>
<td>EN 1081—98: Resilient Floor Coverings—Determination of the Electrical Resistance</td>
<td></td>
</tr>
<tr>
<td>EN</td>
<td></td>
</tr>
<tr>
<td>EN 196</td>
<td>Methods of testing Cement</td>
</tr>
<tr>
<td>GS</td>
<td></td>
</tr>
<tr>
<td>GS 1119</td>
<td>Accessibility Code</td>
</tr>
<tr>
<td>GS 1009</td>
<td>Ghana Wiring Code</td>
</tr>
<tr>
<td>GS 1029</td>
<td>Wood and wood products — Specifications for sawn timber.</td>
</tr>
<tr>
<td>GS 1119</td>
<td>Accessibility Code</td>
</tr>
<tr>
<td>GS 194</td>
<td>Specification for wooden frames for doors, windows and ventilators. Ghana Fire Code</td>
</tr>
<tr>
<td>GS 146</td>
<td>Ghana Labeling Rules.</td>
</tr>
<tr>
<td>GS 1118</td>
<td>Code of practice for wood treatment Plants</td>
</tr>
<tr>
<td>BS</td>
<td>BRITISH STANDARD</td>
</tr>
<tr>
<td>BS EN 12620</td>
<td>Fire detection and alarm systems</td>
</tr>
<tr>
<td>BS EN 1286</td>
<td>Cotton Bales—Dimensions and</td>
</tr>
<tr>
<td>Standard</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>GS IS: 738</td>
<td>Specification for wrought aluminium alloy bolt and screw stock for general purposes.</td>
</tr>
<tr>
<td>GS IS: 740</td>
<td>Specification for wrought aluminium and aluminium alloys, alloyed with copper, for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 1254</td>
<td>Specification for corrugated aluminium alloy plate for Ghana Water and Sewage Cooperation.</td>
</tr>
<tr>
<td>GS IS: 1284</td>
<td>Specification for wrought aluminium alloy bolt and screw stock for general purposes.</td>
</tr>
<tr>
<td>GS IS: 1285</td>
<td>Specification for wrought aluminium and aluminium alloys, extruded round tube and hollow cluses for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 2479</td>
<td>Colour Code for the identification of aluminium and aluminium alloys for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 2676</td>
<td>Dimensions for wrought aluminium and aluminium alloy sheet and strip.</td>
</tr>
<tr>
<td>GS IS: 2677</td>
<td>Dimensions for wrought aluminium and aluminium alloys, plates and hot rolled sheets.</td>
</tr>
<tr>
<td>GS IS: 3043</td>
<td>(Refer to Electrical Regulation 2012, LI 2008).</td>
</tr>
<tr>
<td>GS BS 5286:</td>
<td>Specification for aluminium framed sliding doors.</td>
</tr>
<tr>
<td>GS BS 1161:</td>
<td>Specification for aluminium alloy clauses for structural purposes.</td>
</tr>
<tr>
<td>GS BS 4868:</td>
<td>: Profiled aluminium sheet for vertical application.</td>
</tr>
<tr>
<td>GS BS 4300:</td>
<td>: Specification for wrought aluminium and aluminium alloys for general engineering purposes.</td>
</tr>
<tr>
<td>GS BS EN 485:</td>
<td>: Aluminium and aluminium alloys – Classification of steels.</td>
</tr>
<tr>
<td>GS BS EN 573:</td>
<td>: Aluminium and aluminium alloys – Preferred sizes for wrought metal products.</td>
</tr>
<tr>
<td>GS IS: 1030</td>
<td>Carbon steel casings for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 1136</td>
<td>Preferred sizes for wrought metal products.</td>
</tr>
<tr>
<td>GS IS: 1137</td>
<td>Thickness of sheet and diameter of wire.</td>
</tr>
<tr>
<td>GS IS: 1762</td>
<td>Code for designation of steels.</td>
</tr>
<tr>
<td>GS IS: 2049</td>
<td>Colour Code for the identification of wrought steel for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 2644</td>
<td>High tensile steel casings.</td>
</tr>
<tr>
<td>GS IS: 733</td>
<td>Specification for wrought aluminium and aluminium alloys, bars, rods and plates for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 1797</td>
<td>Specification for low tensile structural steels.</td>
</tr>
<tr>
<td>GS IS: 2062</td>
<td>Specification for steel for general structural purposes.</td>
</tr>
<tr>
<td>GS IS: 2830</td>
<td>Specification for carbon steel billets, ingots, blooms and slabs for re-rolling into steel for general structural purposes.</td>
</tr>
<tr>
<td>GS IS: 2831</td>
<td>Specification for steel ingots and billets for the production of steel wire for the manufacture of wood screws.</td>
</tr>
<tr>
<td>GS IS: 8500</td>
<td>Specification for structural steels microalloyed (medium and high strength qualities).</td>
</tr>
<tr>
<td>GS IS: 8952</td>
<td>Steel ingots, blooms and billets for production of mild steel wire rods for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 277</td>
<td>Specification for galvanized steels sheets (plain and corrugated).</td>
</tr>
<tr>
<td>GS IS: 412</td>
<td>Specification for expanded metal steel sheets for general purposes.</td>
</tr>
<tr>
<td>GS IS: 513</td>
<td>Specification for cold rolled low carbon steel sheets and strips.</td>
</tr>
<tr>
<td>GS IS: 6911</td>
<td>Stainless steel plate, sheet and strip.</td>
</tr>
<tr>
<td>GS IS: 7226</td>
<td>Specification for cold rolled medium, high carbon and low alloy steel strip for general engineering purposes.</td>
</tr>
<tr>
<td>GS IS: 11587</td>
<td>Specification for structural weather resistant steel.</td>
</tr>
<tr>
<td>GS IS: 14246</td>
<td>Specification for continuously casted billets for the manufacture of steel wire coils.</td>
</tr>
<tr>
<td>GS IS: 15103</td>
<td>Specification for fire resistant materials.</td>
</tr>
</tbody>
</table>
APPENDIX A: EMPLOYEE QUALIFICATIONS

The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.

User notes:

About this appendix: Appendix A provides optional criteria for the qualifications for jurisdictions to consider when employing personnel to enforce the building Code. Criteria for the head of the works department, plan reviewers and inspectors are provided.

A.1 HEAD OF WORKS DEPARTMENT QUALIFICATIONS

A.1.1 Head of the works department.
The head of the works department shall have not less than 10 years’ experience or equivalent as a professional architect, engineer, surveyor, planner, or any combination of these, 5 years of which shall have been supervisory experience. The head of the works department shall be appointed by the applicable governing authority.

A.1.2 Chief inspector.
The applicable governing authority shall appoint a chief inspector to administer the provisions of this Code. The chief inspector shall have not less than 10 years’ experience or equivalent as an inspector.

A.1.3 Inspector and plans examiner.
The applicable governing authority shall appoint or employ such number of officers, inspectors, assistants and other employees to administer the Code. Each person shall have at least 2 years of experience as an architect, engineer, surveyor, planner, or any combination of these, and 3 years’ experience as a Higher National Diploma holder (HND) and 5 years for technicians, foreman or competent mechanic in charge of construction.

A.1.4 Removal from Office.
Employees in the position of head of the works department, chief inspector or inspector shall not be removed from office except for cause after full opportunity has been given to be heard on specific charges before such applicable governing authority.

APPENDIX B: BOARD OF APPEALS

The provisions contained in this appendix are mandatory.

User notes:

About this appendix: Appendix B provides criteria for Board of Appeals members. Also provided are procedures by which the Board of Appeals should conduct its business.

B.1 GENERAL

B.1.1 Application.
Applications for appeal shall be obtained from the head of the works department. Applications shall be filed within 20 days after notice has been served.

B.1.2 Membership of board.
The board of appeals shall consist of persons appointed by the chief appointing authority as follows:

1. One for 5 years; one for 4 years; one for 3 years; one for 2 years; and one for 1 year.

2. Thereafter, each new member shall serve for 5 years or until a successor has been appointed.

The head of the works department shall be an ex officio member of said board but shall have no vote on any matter before the board.

B.1.2.1 Alternate members.
The chief appointing authority shall appoint two alternate members who shall be called by the board chairperson to hear appeals during the absence or disqualification of a member. Alternate members shall possess the qualifications required for board membership and shall be appointed for 5 years, or until a successor has been appointed.

B.1.2.2 Qualifications.
The board of appeals shall consist of five individuals, one from each of the following professions or disciplines:

1. Registered architect or building technologist with not fewer than 10 years of experience, 5 of which shall have been in responsible charge of work.
2. Registered structural engineer with not fewer than 10 years of experience, 5 of which shall have been in responsible charge of work.

3. Registered mechanical engineer with not fewer than 10 years of experience, 5 of which shall have been in responsible charge of work.

4. Registered electrical engineer with not fewer than 10 years of experience, 5 of which shall have been in responsible charge of work.

5. Registered fire protection engineer with not fewer than 10 years of experience, 5 of which shall have been in responsible charge of work.

B.1.2.3 Rules and procedures.
The board is authorized to establish policies and procedures necessary to carry out its duties.

B.1.2.4 Chairperson.
The board shall annually select one of its members to serve as chairperson.

B.1.2.5 Disqualification of member.
A member shall not hear an appeal in which that member has a personal, professional or financial interest.

B.1.2.6 Secretary.
The Coordinating Director shall designate a qualified clerk to serve as secretary to the board. The Secretary shall file a detailed record of all proceedings in the office of the Coordinating Director.

B.1.2.7 Compensation of members.
Compensation of members shall be determined by law.

B.1.3 Notice of meeting.
The board shall meet upon notice from the chairperson, within 10 days of the filing of an appeal or at stated periodic meetings.

APPENDIX C RODENTS CONTROL

User notes:
About this appendix: The provisions of Appendix F are minimum mechanical methods to prevent the entry of rodents into a building. These standards, when used in department and any person whose interests are affected shall be given an opportunity to be heard.

B.1.3.2 Procedure.
The board shall adopt and make available to the public through the secretary procedures under which a hearing will be conducted. The procedures shall not require compliance with strict rules of evidence, but shall mandate that only relevant information be received.

B.1.3.3 Postponed hearing.
When five members are not present to hear an appeal, either the appellant or the appellant’s representative shall have the right to request a postponement of the hearing.

B.1.4 Board decision.
The board shall modify or reverse the decision of the head of the works department by a concurring vote of two-thirds of its members.

B.1.4.1 Resolution.
The decision of the board shall be by resolution. Certified copies shall be furnished to the appellant and to the head of the works department.

B.1.4.2 Administration.
The head of the works department shall take immediate action in accordance with the decision of the board.
C1.1 GENERAL
C1.1.1 General.
Buildings or structures and the walls enclosing habitable or occupiable rooms and spaces in which persons live, sleep or work, or in which feed, food or foodstuffs are stored, prepared, processed, served or sold, shall be constructed in accordance with the provisions of this clause.

C1.1.2 Foundation wall ventilation openings.
Foundation wall ventilation openings shall be covered for their height and width with perforated sheet metal plates not less than 1.8 mm (0.070 inch) thick, expanded sheet metal plates not less than 1.2 mm (0.047 inch) thick, cast-iron grills or grating, extruded aluminum load-bearing vents or with hardware cloth of 0.89 mm (0.035 inch) wire or heavier. The openings therein shall not exceed 6.4 mm (1/4 inch).

C1.1.3 Foundation and exterior wall sealing.
Annular spaces around pipes, electric cables, conduits or other openings in the walls shall be protected against the passage of rodents by closing such openings with cement mortar, concrete masonry or noncorrosive metal or caulking materials.

C1.1.4 Doors.
Doors on which metal protection has been applied shall be hinged so as to be free swinging. When closed, the maximum clearance between any door, door jambs and sills shall be not greater than 9.5 mm (3/8 inch).

C1.1.5 Windows and other openings.
Windows and other openings for the purpose of light or ventilation located in exterior walls within 610 mm (2 feet) above the existing ground level immediately below such opening shall be covered for their entire height and width, including frame, with hardware cloth of not less than 0.89 mm (0.035-inch) wire or heavier.

C1.1.5.1 Rodent-accessible openings.
Windows and other openings for the purpose of light and ventilation in the exterior walls not covered in this appendix, accessible to rodents by way of exposed pipes, wires, conduits and other appurtenances, shall be covered with wire cloth of at least 0.89 mm (0.035-inch) openings. In lieu of wire cloth covering, said pipes, wires, conduits and other appurtenances shall be blocked from rodent usage by installing solid sheet metal guards 0.61 mm (0.024 inch) thick or heavier. Guards shall be fitted around pipes, wires, conduits or other appurtenances. In addition, they shall be fastened securely to and shall extend perpendicularly from the exterior wall for not less than 305 mm (12 inches) beyond and on either side of pipes, wires, conduits or appurtenances.

C1.1.6 Pier and wood construction.
C1.1.6.1 Sill less than 300 mm (12 inches) above ground.
Buildings not provided with a continuous foundation shall be provided with protection against rodents at grade by providing either an apron in accordance with Clause C1.1.6.1.1 or a floor slab in accordance with Clause C1.1.6.1.2.

C1.1.6.1.1 Apron.
Where an apron is provided, the apron shall be not less than 203 mm (8 inches) above, nor less than 610 mm (24 inches) below, grade. The apron shall not terminate below the lower edge of the siding material. The apron shall be constructed of an approved nondecayable, water-resistant rodentproofing material of required strength and shall be installed around the entire perimeter of the building. Where constructed of masonry or concrete materials, the apron shall be not less than 102 mm (4 inches) in thickness.

C1.1.6.1.2 Grade floors.
Where continuous concrete-grade floor slabs are provided, open spaces shall not be left between the slab and walls, and openings in the slab shall be protected.

C1.1.6.2 Sill at or above 12 inches above ground.
Buildings not provided with a continuous foundation and that have sills 305 mm (12 inches) or more above ground level shall be provided with protection against rodents at grade in accordance with any of the following:

1. Clause C1.1.6.1.1 or C1.1.6.1.2.
2. By installing solid sheet metal collars not less than 0.6 mm (0.024 inch) thick at the top of...
each pier or pile and around each pipe, cable, conduit, wire or other item that provides a continuous pathway from the ground to the floor.

3. By encasing the pipes, cables, conduits or wires in an enclosure constructed in accordance with Clause C1.1.6.1.1.

The purpose of this appendix is to promote the public health, safety and general welfare and to minimize public and private losses due to flood conditions in specific flood hazard areas through the establishment of comprehensive regulations for management of flood hazard areas designed to:

1. Prevent unnecessary disruption of commerce, access and public service during times of flooding.

2. Manage the alteration of natural flood plains, stream channels and shorelines.

3. Manage filling, grading, dredging and other development that may increase flood damage or erosion potential.

4. Prevent or regulate the construction of flood barriers that will divert floodwaters or that can increase flood hazards.

5. Contribute to improved construction techniques in the flood plain.

D1.1.2 Objectives.
The objectives of this appendix are to protect human life, minimize the expenditure of public money for flood control projects, minimize the need for rescue and relief efforts associated with flooding, minimize prolonged business interruption, minimize damage to public facilities and utilities, help maintain a stable tax base by providing for the sound use and development of flood-prone areas, contribute to improved construction techniques in the flood plain and ensure that potential owners and occupants are notified that property is within flood hazard areas.

D1.1.3 Scope.
The provisions of this appendix shall apply to all proposed development in a flood hazard area.

D1.1.4 Violations.
Any violation of a provision of this appendix, or failure to comply with a permit or variance issued pursuant to this appendix or any requirement of this appendix, shall be handled in accordance with Clause 1.16.1

APPENDIX D: FLOOD-RESISTANT CONSTRUCTION

User notes:
This Appendix is intended to provide additional flood management and administrative requirements.

D1.1 ADMINISTRATION

D1.1.1 Purpose.
D1.2 APPLICABILITY

D1.2.1 General.
This appendix, in conjunction with this Code, provides minimum requirements for development located in flood hazard areas, including:

1. The subdivision of land.

2. Site improvements and installation of utilities.

3. Placement and replacement of manufactured homes.


5. New construction and repair, reconstruction, rehabilitation or additions to new construction.

6. Substantial improvement of existing buildings and structures, including restoration after damage.

7. Installation of tanks.

8. Temporary structures.

9. Temporary or permanent storage, utility and miscellaneous Group U buildings and structures.

10. Certain building work exempt from permit under Clause 1.6.2 and other buildings and development activities.

D1.2.2 Establishment of flood hazard areas.
Flood hazard areas established by the applicable governing authority shall apply.

D1.3 Permit applications.

D1.3.1 All applications for permits must comply with the following:

1. The head of the works department shall review all permit applications to determine whether proposed development is located in flood hazard areas established in Clause D1.2.2.

2. Where a proposed development site is in a flood hazard area, all development to which this appendix is applicable as specified in Clause D1.2.1 shall be designed and constructed with methods, practices and materials that minimize flood damage and that are in accordance with this Code and the Relevant Flood Resistant Design and Construction Code.

D1.3.2 Other permits.
It shall be the responsibility of the head of the works department to ensure that approval of a proposed development shall not be given until proof that necessary permits have been granted by authorized government agencies having jurisdiction over such development.

D1.3.3 Determination of design flood elevations.
If design flood elevations are not specified, the head of the works department is authorized to require the applicant to meet one of the following:

1. Obtain, review and reasonably utilize data available from an authorized government agency.

2. Determine the design flood elevation in accordance with accepted hydrologic and hydraulic engineering techniques. Such analyses shall be performed and sealed by a registered design professional. Studies, analyses and computations shall be submitted in sufficient detail to allow review and approval by the head of the works department. The accuracy of data submitted for such determination shall be the responsibility of the applicant.

D1.3.4 Activities in riverine flood hazard areas.
In riverine flood hazard areas where design flood elevations are specified but floodways have not been designated, the head of the works department shall not permit any new construction, substantial improvement or other development, including fill, unless the applicant submits an engineering analysis
D1.3.5 Floodway encroachment. 
Prior to issuing a permit for any floodway encroachment, including fill, new construction, substantial improvements and other development or land-disturbing activity, the head of the works department shall require submission of a certification, prepared by a registered design professional, along with supporting technical data, demonstrating that such development will not cause any increase of the base flood level.

D1.3.6 Watercourse alteration. 
Prior to issuing a permit for any alteration or relocation of any watercourse, the head of the works department shall require submission of an engineering analysis, prepared by a registered design professional, demonstrating that the flood-carrying capacity of the altered or relocated portion of the watercourse will not be decreased. Such watercourses shall be maintained in a manner that preserves the channel’s flood-carrying capacity.

D1.3.7 Alterations in coastal areas. 
Prior to issuing a permit for any alteration of sand dunes and mangrove stands in coastal high-hazard areas, the head of the works department shall require submission of an engineering analysis, prepared by a registered design professional, demonstrating that the proposed alteration will not increase the potential for flood damage.

D1.3.8 Records. 
The head of the works department shall maintain a permanent record of all permits issued in flood hazard areas, including supporting certifications and documentation required by this appendix and copies of inspection reports, design certifications and documentation of elevations required in this Code.

D1.3.9 Inspections. 
Development for which a permit under this appendix is required shall be subject to inspection. The head of the works department or the head of the works department’s designee shall make, or cause to be made, inspections of all development in flood hazard areas authorized by issuance of a permit under this appendix.

D1.4 PERMITS

D1.4.1 Required. 
Any person, owner or owner’s authorized agent who intends to conduct any development in a flood hazard area shall first make application to the head of the works department and shall obtain the required permit.

D1.4.2 Application for permit. 
The applicant shall file an application in writing on a form furnished by the head of the works department. Such application shall:

1. Identify and describe the development to be covered by the permit.

2. Describe the land on which the proposed development is to be conducted by legal description, street address or similar description that will readily identify and definitely locate the site.

3. Include a site plan showing the delineation of flood hazard areas, floodway boundaries, flood zones, design flood elevations, ground elevations, proposed fill and excavation and drainage patterns and facilities.

4. Include in subdivision proposals and other proposed developments with more than 50 plots or larger than 20 234 m² (5 acres), base flood elevation data, if such data are not identified for the flood hazard areas established in Clause G1.2.2.

5. Indicate the use and occupancy for which the proposed development is intended.
6. Be accompanied by construction documents, grading and filling plans and other information deemed appropriate by the head of the works department.

7. State the valuation of the proposed work.

8. Be signed by the applicant or the applicant’s authorized agent.

D1.4.3 Validity of permit.
The issuance of a permit under this appendix shall not be construed to be a permit for, or approval of, any violation of this appendix or any other legislation. The issuance of a permit based on submitted documents and information shall not prevent the head of the works department from requiring the correction of errors. The head of the works department is authorized to prevent occupancy or use of a structure or site that is in violation of this appendix or other legislation.

D1.4.4 Expiration.
A permit shall become invalid if the proposed development is not commenced within 180 days after its issuance, or if the work authorized is suspended or abandoned for a period of 180 days after the work commences. Extensions shall be requested in writing and justifiable cause demonstrated. The head of the works department is authorized to grant, in writing, one or more extensions of time, for periods not more than 180 days each.

D1.4.5 Suspension or revocation.
The head of the works department is authorized to suspend or revoke a permit issued under this appendix wherever the permit is issued in error or on the basis of incorrect, inaccurate or incomplete information, or in violation of any legislation.

D1.5 VARIANCES
D1.5.1 General.
The board of appeals established in this Code shall hear and decide requests for variances. The board of appeals shall base its determination on technical justifications, and has the right to attach such conditions to variances as it deems necessary to further the purposes and objectives of this appendix.

D1.5.2 Records.
The head of the works department shall maintain a permanent record of all variance actions, including justification for their issuance.

D1.5.3 Historic structures.
A variance is authorized to be issued for the repair or rehabilitation of a historic structure upon a determination that the proposed repair or rehabilitation will not preclude the structure’s continued designation as a historic structure, and the variance is the minimum necessary to preserve the historic character and design of the structure.

Exception: Within flood hazard areas, historic structures that do not meet one or more of the following designations:

1. Listed or preliminarily determined to be eligible for listing in the National Register of Historic Places.

2. Determined by the appropriate government agency as contributing to the historical significance.

3. Designated as historic under a national or local historic preservation program that is approved by the Department of Interior.

D1.5.4 Functionally dependent facilities.
A variance is authorized to be issued for the construction or substantial improvement of a functionally dependent facility provided that the criteria in this Code are met and the variance is the minimum necessary to allow the construction or substantial improvement, and that all due consideration has been given to methods and materials that minimize flood damages during the design flood and do not create additional threats to public safety.

D1.5.5 Restrictions.
The board of appeals shall not issue a variance for any proposed development in a floodway if any increase in flood levels would result during the base flood discharge.

D1.5.6 Considerations.
In reviewing applications for variances, the board of appeals shall consider all technical evaluations, all relevant factors, all other portions of this appendix and the following:
1. The danger that materials and debris may be swept onto other lands resulting in further injury or damage.

2. The danger to life and property due to flooding or erosion damage.

3. The susceptibility of the proposed development, including contents, to flood damage and the effect of such damage on current and future owners.

4. The importance of the services provided by the proposed development to the community.

5. The availability of alternate locations for the proposed development that are not subject to flooding or erosion.

6. The compatibility of the proposed development with existing and anticipated development.

7. The relationship of the proposed development to the comprehensive plan and flood plain management program for that area.

8. The safety of access to the property in times of flood for ordinary and emergency vehicles.

9. The expected heights, velocity, duration, rate of rise and debris and sediment transport of the floodwaters and the effects of wave action, if applicable, expected at the site.

10. The costs of providing governmental services during and after flood conditions including maintenance and repair of public utilities and facilities such as sewer, gas, electrical and water systems, streets and bridges.

D1.5.7 Conditions for issuance.
Variances shall only be issued by the board of appeals where all of the following criteria are met:

1. A design and technique showing good and sufficient cause that the unique characteristics of the size, configuration or topography of the site renders the established flood elevation standards inappropriate.

2. A determination that failure to grant the variance would result in exceptional hardship by rendering the plot undevelopable.

3. A determination that the granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, nor create nuisances, cause fraud on or victimization of the public or conflict with existing legislation.

4. A determination that the variance is the minimum necessary, considering the flood hazard, to afford relief.

5. Notification to the applicant in writing over the signature of the head of the works department that the issuance of a variance to construct a structure below the base flood level will result in increased premium rates for flood insurance and that such construction below the base flood level increases risks to life and property.

D2.1 DEFINITIONS

D2.1.1 General.
The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Part 2 of this Code for general definitions.

D2.1.2 Definitions.

DEVELOPMENT. Any man-made change to improved or unimproved real estate, including but not limited to, buildings or other structures, temporary structures, temporary or permanent storage of materials, mining, dredging, filling, grading, paving, excavations, operations and other land-disturbing activities.

FUNCTIONALLY DEPENDENT FACILITY. A facility that cannot be used for its intended purpose unless it is located or carried out in close proximity to water, such as a docking or port facility necessary for the loading or unloading of cargo or passengers, shipbuilding or ship repair. The term does not include long-term storage, manufacture, sales or service facilities.
MANUFACTURED HOME. A structure that is transportable in one or more clauses, built on a permanent chassis, designed for use with or without a permanent foundation when attached to the required utilities, and constructed to meet Safety Standards, rules and regulations. The term also includes mobile homes, park trailers, travel trailers and similar transportable structures that are placed on a site for 180 consecutive days or longer.

RECREATIONAL VEHICLE. A vehicle that is built on a single chassis, 37.16 m (400 square feet) or less when measured at the largest horizontal projection, designed to be selfpropelled or permanently towable by a light-duty truck, and designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel or seasonal use. A recreational vehicle is ready for highway use if it is on its wheels or jacking system, is attached to the site only by quick disconnect-type utilities and security devices and has no permanently attached additions.

VARIANCE. A grant of relief from the requirements of this clause that permits construction in a manner otherwise prohibited by this clause where specific enforcement would result in unnecessary hardship.

D3.1 SUBDIVISIONS

D3.1.1 General.
Any subdivision proposal, including proposals for manufactured home parks and subdivisions, or other proposed new development in a flood hazard area shall be reviewed to verify all of the following:

1. Such proposals are consistent with the need to minimize flood damage.

2. Public utilities and facilities, such as sewer, gas, electric and water systems, are located and constructed to minimize or eliminate flood damage.

3. Adequate drainage is provided to reduce exposure to flood hazards.

D3.1.2 Subdivision requirements.
The following requirements shall apply in the case of any proposed subdivision, including proposals for manufactured home parks and subdivisions, any portion of which lies within a flood hazard area:

1. The flood hazard area, including floodways, coastal high-hazard areas, as appropriate, shall be delineated on tentative and final subdivision maps.

2. Design flood elevations shall be shown on tentative and final subdivision maps.

3. Residential building plots shall be provided with adequate buildable area outside the floodway.

4. The design criteria for utilities and facilities set forth in this appendix and appropriate International Codes shall be met.

D4.1 SITE IMPROVEMENT

D4.1.1 Development in floodways.
Development or land-disturbing activity shall not be authorized in the floodway.

D4.1.2 Coastal high-hazard areas and coastal zones.
In coastal high-hazard areas and coastal zones:

1. New buildings and buildings that are substantially improved shall only be authorized landward of the reach of mean high tide.

2. The use of fill for structural support of buildings is prohibited.

D4.1.3 Sewer facilities.
All new or replaced sanitary sewer facilities, private sewage treatment plants (including all pumping stations and collector systems) and on-site waste disposal systems shall be designed to minimize or eliminate infiltration of floodwaters into the facilities and discharge from the facilities into floodwaters, or impairment of the facilities and systems.

D4.1.4 Water facilities.
All new or replacement water facilities shall be designed to minimize or eliminate infiltration of floodwaters into the systems.
D4.1.5 Storm drainage.
Storm drainage shall be designed to convey
the flow of surface waters to minimize or
eliminate damage to persons or property.

D4.1.6 Streets and sidewalks.
Streets and sidewalks shall be designed to
minimize potential for increasing or
aggravating flood levels.

D5.1 MANUFACTURED HOMES

D5.1.1 Elevation.
All new and replacement manufactured homes
to be placed or substantially improved in a
flood hazard area shall be elevated such that
the lowest floor of the manufactured home is
elevated to or above the design flood
elevation.

D5.1.2 Foundations.
All new and replacement manufactured
homes, including substantial improvement of
existing manufactured homes, shall be placed
on a permanent, reinforced foundation that is
designed in accordance with this Code.

D5.1.3 Anchoring.
All new and replacement manufactured homes
to be placed or substantially improved in a
flood hazard area shall be installed using
methods and practices that minimize flood
damage. Manufactured homes shall be
securely anchored to an adequately anchored
foundation system to resist floatation, collapse
and lateral movement. Methods of anchoring
are authorized to include, but are not limited to,
use of over-the-top or frame ties to ground
anchors. This requirement is in addition to
applicable state and local anchoring
requirements for resisting wind forces.

D5.1.4 Protection of mechanical equipment
and outside appliances.
Mechanical equipment and outside appliances
shall be elevated to or above the design flood
elevation.

Exception: Where such equipment and
appliances are designed and installed to
prevent water from entering or accumulating
within their components and the systems are
constructed to resist hydrostatic and
hydrodynamic loads and stresses, including
the effects of buoyancy, during the occurrence
of flooding up to the elevation required by this
Code. The systems and equipment shall be
permitted to be located below the elevation
required by this Code. Electrical wiring
systems shall be permitted below the design
flood elevation provided that they conform to
the provisions of Ghana Wiring Code.

D5.1.5 Enclosures.
Fully enclosed areas below elevated
manufactured homes shall comply with the
requirements of this Code.

D6.1 RECREATIONAL VEHICLES
D6.1.1 Placement prohibited.
The placement of recreational vehicles shall
not be authorized in coastal high-hazard areas
and in floodways.

D6.1.2 Temporary placement.
Recreational vehicles in flood hazard areas
shall be fully licensed and ready for highway
use, or shall be placed on a site for less than
180 consecutive days.

D6.1.3 Permanent placement.
Recreational vehicles that are not fully
licensed and ready for highway use, or that
are to be placed on a site for more than 180
consecutive days, shall meet the requirements
of Clause G5.1 for manufactured homes.

D7.1 TANKS

D7.1.1 Tanks.
Underground and above-ground tanks shall be
designed, constructed, installed and anchored
in accordance with the relevant Flood
Resistant design and Construction Code.

D8.1 OTHER BUILDING WORK
D8.1.1 Garages and accessory structures.
Garages and accessory structures shall be
designed and constructed in accordance with
the relevant Flood Resistant design and
Construction Code.

D8.1.2 Fences.
Fences in floodways that have the potential to
block the passage of floodwaters, such as
stockade fences and wire mesh fences, shall
meet the requirement of Clause D1.3.5.

D8.1.3 Oil derricks.
Oil derricks located in flood hazard areas shall
be designed in conformance with the flood
loads.

D8.1.4 Retaining walls, sidewalks and
driveways.
Retaining walls, sidewalks and driveways shall
meet the requirements of Clause 18.4.5.
D8.1.5 Swimming pools.
Swimming pools shall be designed and constructed in accordance with the relevant Flood Resistant design and Construction Code. Above-ground swimming pools, on-ground swimming pools and in-ground swimming pools that involve placement of fill in floodways shall also meet the requirements of Clause D1.3.5.

D8.1.6 Decks, porches, and patios.
Decks, porches and patios shall be designed and constructed in accordance with the Relevant Flood Resistant Design and Construction Code.

D8.1.7 Nonstructural concrete slabs in coastal high-hazard areas and coastal A zones.
In coastal high-hazard areas and coastal A zones, nonstructural concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios and similar nonstructural uses are permitted beneath or adjacent to buildings and structures provided that the concrete slabs shall be constructed in accordance with the relevant Flood Resistant Design and Construction Code.

D8.1.8 Roads and watercourse crossings in regulated floodways.
Roads and watercourse crossings that encroach into regulated floodways, including roads, bridges, culverts, low-water crossings and similar means for vehicles or pedestrians to travel from one side of a watercourse to the other, shall meet the requirement of Clause D1.3.5.

D9.1 TEMPORARY STRUCTURES AND TEMPORARY STORAGE
D9.1.1 Temporary structures.
Temporary structures shall be erected for a period of less than 180 days. Temporary structures shall be anchored to prevent flotation, collapse or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood. Fully enclosed temporary structures shall have flood openings that are in accordance with the relevant Flood Resistant Design and Construction Code to allow for the automatic entry and exit of floodwaters.

D9.1.2 Temporary storage.
Temporary storage includes storage of goods and materials for a period of less than 180 days. Stored materials shall not include hazardous materials.

D9.1.3 Floodway encroachment.
Temporary structures and temporary storage in floodways shall meet the requirements of D1.3.5.

D10.1 UTILITY AND MISCELLANEOUS GROUP U
D10.1.1 Utility and miscellaneous Group U.
Utility and miscellaneous Group U includes buildings that are accessory in character and miscellaneous structures not classified in any specific occupancy in this Code, including, but not limited to, agricultural buildings, aircraft hangars (accessory to a one- or two-family residence), barns, carports, fences more than 1829 mm (6 feet) high, grain silos (accessory to a residential occupancy), greenhouses, livestock shelters, private garages, retaining walls, sheds, stables and towers.

D10.1.2 Flood loads.
Utility and miscellaneous Group U buildings and structures, including substantial improvement of such buildings and structures, shall be anchored to prevent flotation, collapse or lateral movement resulting from flood loads, including the effects of buoyancy, during conditions of the design flood.

D10.1.3 Elevation.
Utility and miscellaneous Group U buildings and structures, including substantial improvement of such buildings and structures, shall be elevated such that the lowest floor, including basement, is elevated to or above the design flood elevation in accordance with Clause 1612 of this Code.

D10.1.4 Enclosures below design flood elevation.
Fully enclosed areas below the design flood elevation shall be constructed in accordance with the relevant Flood Resistant Design and Construction Code.

D10.1.5 Flood-damage-resistant materials.
Flood-damage-resistant materials shall be used below the design flood elevation.

D10.1.6 Protection of mechanical, plumbing and electrical systems.
Mechanical, plumbing and electrical systems, including plumbing fixtures, shall be elevated to or above the design flood elevation.

Exception: Electrical systems, equipment and components; heating, ventilating, air conditioning and plumbing appliances; plumbing fixtures, duct systems and other service equipment shall be permitted to be...
located below the design flood elevation provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the design flood elevation in compliance with the flood-resistant construction requirements of this Code. Electrical wiring systems shall be permitted to be located below the design flood elevation provided that they conform to the provisions of Ghana Wiring Code

D11.1 REFERENCED STANDARDS

THE RELEVANT Flood D1.3.1, FLOOD Resistant D1.3, RESISTANT Design and D4.1.4, DESIGN AND Construction D7.1.1, CONSTRUCTION CODE—13 D8.1.1, D8.1.5, D8.1.6, D8.1.7, D9.1.1, D10.1.4

APPENDIX E: OUTDOOR SIGNAGE

User notes:
About this appendix: Appendix E gathers in one place the various standards that regulate the construction and protection of outdoor signs. Wherever possible, the appendix provides standards in performance language, thus allowing the widest possible application.

E.1 GENERAL

E.1.1 General.
A sign shall not be erected in a manner that would confuse or obstruct the view of or interfere with exit signs required by Part 11 or with official traffic signs, signals or devices. Signs and sign support structures, together with their supports, braces, guys and anchors, shall be kept in repair and in proper state of preservation. The display surfaces of signs shall be kept neatly painted or posted at all times.

E.1.2 Signs exempt from permits.
The following signs are exempt from the requirements to obtain a permit before erection:

2. Temporary signs announcing the sale or rent of property.

3. Signs erected by transportation authorities.

4. Projecting signs not exceeding 0.23 m² (2.5 square feet).

5. The changing of moveable parts of an approved sign that is designed for such changes, or the repainting or repositioning of display matter shall not be deemed an alteration.

E.2 DEFINITIONS

E.2.1 General.
The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Part 2 of this Code for general definitions.

COMBINATION SIGN. A sign incorporating any combination of the features of pole, projecting and roof signs.

DISPLAY SIGN. The area made available by the sign structure for the purpose of displaying the advertising message.

ELECTRIC SIGN. A sign containing electrical wiring, but not including signs illuminated by an exterior light source.

GROUND SIGN. A billboard or similar type of sign that is supported by one or more uprights, poles or braces in or upon the ground other than a combination sign or pole sign, as defined by this Code.

POLE SIGN. A sign wholly supported by a sign structure in the ground.

PORTABLE DISPLAY SURFACE. A display surface temporarily fixed to a standardized advertising structure that is regularly moved from structure to structure at periodic intervals.

PROJECTING SIGN. A sign other than a wall sign that projects from and is supported by a wall of a building or structure.

ROOF SIGN. A sign erected on or above a roof or parapet of a building or structure.

SIGN. Any letter, figure, character, mark, plane, point, marquee sign, design, poster, pictorial, picture, stroke, stripe, line, trademark,
reading matter or illuminated service, which shall be constructed, placed, attached, painted, erected, fastened or manufactured in any manner whatsoever, so that the same shall be used for the attraction of the public to any place, subject, person, firm, corporation, public performance, article, machine or merchandise, whatsoever, which is displayed in any manner outdoors. Every sign shall be classified and conform to the requirements of that classification as set forth in this part.

**SIGN STRUCTURE.** Any structure that supports or is capable of supporting a sign as defined in this Code. A sign structure is permitted to be a single pole and is not required to be an integral part of the building.

**WALL SIGN.** Any sign attached to or erected against the wall of a building or structure, with the exposed face of the sign in a plane parallel to the plane of said wall.

**E.3 LOCATION**

**E.3.1 Location restrictions.** Signs shall not be erected, constructed or maintained so as to obstruct any fire escape or any window or door or opening used as a means of escape or so as to prevent free passage from one part of a roof to any other part thereof. A sign shall not be attached in any form, shape or manner to a fire escape, nor be placed in such manner as to interfere with any opening required for ventilation.

**E.4 IDENTIFICATION**

**E.4.1 Identification.** Every outdoor advertising display sign hereafter erected, constructed or maintained, for which a permit is required, shall be plainly marked with the name of the person, firm or corporation erecting and maintaining such sign and shall have affixed on the front thereof the permit number issued for said sign or other method of identification approved by the head of the works department.

**E.5 DESIGN AND CONSTRUCTION**

**E.5.1 General requirements.** Signs shall be designed and constructed to comply with the provisions of this Code for use of materials, loads and stresses.

**E.5.2 Permits, drawings and specifications.** Where a permit is required, as provided in part 1, construction documents shall be required.

These documents shall show the dimensions, material and required details of construction, including loads, stresses and anchors.

**E.5.3 Wind load.** Signs shall be designed and constructed to withstand wind pressure as provided for in Part 17.

**E.5.4 Seismic load.** Signs designed to withstand wind pressures shall be considered capable of withstanding earthquake loads, except as provided for in Part 17.

**E.5.5 Working stresses.** In outdoor advertising display signs, the allowable working stresses shall conform to the requirements of Part 17. The working stresses of wire rope and its fastenings shall not exceed 25 percent of the ultimate strength of the rope or fasteners.

**Exceptions:**

1. The allowable working stresses for steel and wood shall be in accordance with the provisions of Part 23 and 24.

2. The working strength of chains, cables, guys or steel rods shall not exceed one-fifth of the ultimate strength of such chains, cables, guys or steel.

**E.5.6 Attachment.** Signs attached to masonry, concrete or steel shall be safely and securely fastened by means of metal anchors, bolts or approved expansion screws of sufficient size and anchorage to safely support the loads applied.

**E.6 ELECTRICAL**

**E.6.1 Illumination.** A sign shall not be illuminated by other than electrical means, and electrical devices and wiring shall be installed in accordance with the requirements of Ghana wiring Code. Any open spark or flame shall not be used for display purposes unless specifically approved.

**E.6.1.1 Internally illuminated signs.** Except as provided for in Clause 27.11, where internally illuminated signs have facings of wood or of approved plastic complying with the
requirements of Clause 27.6.4, the area of such facing clause shall be not more than $11.16 \text{ m}^2$ (120 square feet) and the wiring for electric lighting shall be entirely enclosed in the sign cabinet with a clearance of not less than 51 mm (2 inches) from the facing material. The dimensional limitation of $11.16 \text{ m}^2$ (120 square feet) shall not apply to sign facing clauses made from flame-resistant-coated fabric (ordinarily known as “flexible sign face plastic”) that weighs less than 678 g/m$^2$ (20 ounces per square yard) and that, when tested in accordance with NFPA 701, meets the fire propagation performance requirements of both Test 1 and Test 2 or that, when tested in accordance with an approved test method, exhibits an average burn time of 2 seconds or less and a burning extent of 150 mm (5.9 inches) or less for 10 specimens.

E.6.2 Electrical service.
Signs that require electrical service shall comply with Ghana wiring Code.

E.7 COMBUSTIBLE MATERIALS

E.7.1 Use of combustibles.
Wood, plastics complying with the requirements of Clause E1.7.1.1 or plastic finish panels as provided for in Part 27, or other materials of combustible characteristics similar to wood, used for moldings, cappings, nailing blocks, letters and latticing, shall comply with Clause H109.1 and shall not be used for other ornamental features of signs, unless approved.

E1.7.1.1 Plastic materials.
Notwithstanding any other provisions of this Code, plastics that burn at a rate not faster than 64 mm/s (2.5 inches per minute) when tested in accordance with ASTM D635 shall be approved for use as the display surface material and for the letters, decorations and facings on signs and outdoor display structures.

E.7.1.2 Electric sign faces.
Individual plastic facings of electric signs shall not exceed $18.6 \text{ m}^2$ (200 square feet) in area.

E.7.1.3 Area limitation.
If the area of a display surface exceeds $18.6 \text{ m}^2$ (200 square feet), the area occupied or covered by plastics complying with the requirements of Clause E1.7.1.1 shall be limited to $18.6 \text{ m}^2$ (200 square feet) plus 50 percent of the difference between $18.6 \text{ m}^2$ (200 square feet) and the area of display surface. The area of plastic on a display surface shall not in any case exceed $102 \text{ m}^2$ (1,100 square feet).

E.7.1.4 Plastic appurtenances.
Letters and decorations mounted on a plastic facing or display surface can be made of plastics complying with the requirements of Clause E1.7.1.1.

E.8 ANIMATED DEVICES

E.8.1 Fail-safe device.
Signs that contain moving clauses or ornaments shall have fail-safe provisions to prevent the clause or ornament from releasing and falling or shifting its center of gravity more than 381 mm (15 inches). The fail-safe device shall be in addition to the mechanism and the mechanism’s housing that operate the movable clause or ornament. The fail-safe device shall be capable of supporting the full dead weight of the clause or ornament when the moving mechanism releases.

E.9 GROUND SIGNS

E.9.1 Height restrictions.
The structural frame of ground signs shall not be erected of combustible materials to a height of more than 10 668 mm (35 feet) above the ground. Ground signs constructed entirely of noncombustible material shall not be erected to a height of greater than 30 480 mm (100 feet) above the ground. Greater heights are permitted where approved and located so as not to create a hazard or danger to the public.

E.9.2 Required clearance.
The bottom coping of every ground sign shall be not less than 914 mm (3 feet) above the ground or street level, which space can be filled with platform decorative trim or light wooden construction.

E.9.3 Wood anchors and supports.
Where wood anchors or supports are embedded in the soil, the wood shall be pressure treated with an approved preservative.

E.10 ROOF SIGNS

E.10.1 General.
Roof signs shall be constructed entirely of metal or other approved noncombustible material except as provided for in Clauses H.6.1.1 and H107.1. Provisions shall be made for electric grounding of metallic parts. Where combustible materials are permitted in letters or other ornamental features, wiring and tubing shall be kept free and insulated therefrom. Roof signs shall be so constructed as to leave a clear space of not less than 1829 mm (6 feet) between the roof level and the lowest part of the sign and shall have not less than 1524 mm (5 feet) clearance between the vertical supports thereof. Roof sign structures shall not project beyond an exterior wall.

**Exception:** Signs on flat roofs with every part of the roof accessible.

E.10.2 Bearing plates.
The bearing plates of roof signs shall distribute the load directly to or on masonry walls, steel roof girders, columns or beams. The building shall be designed to avoid overstress of these members.

E.10.3 Height of solid signs.
A roof sign having a solid surface shall not exceed, at any point, a height of 7315 mm (24 feet) measured from the roof surface.

E.10.4 Height of open signs.
Open roof signs in which the uniform open area is not less than 40 percent of total gross area shall not exceed a height of 22 860 mm (75 feet) on buildings of Type 1 or Type 2 construction. On buildings of other construction types, the height shall not exceed 40 feet (12 192 mm). Such signs shall be thoroughly secured to the building on which they are installed, erected or constructed by iron, metal anchors, bolts, supports, chains, stranded cables, steel rods or braces and they shall be maintained in good condition.

E.10.5 Height of closed signs.
A closed roof sign shall not be erected to a height greater than 15 240 mm (50 feet) above the roof of buildings of Type 1 or 2 construction or more than 10 668 mm (35 feet) above the roof of buildings of Type 3, 4 or 5 construction.

E.11 WALL SIGNS
E.11.1 Materials.
Wall signs that have an area exceeding 3.72 m² (40 square feet) shall be constructed of metal or other approved noncombustible material, except for nailing rails and as provided for in Clauses H106.1.1 and H107.1.

E.11.2 Exterior wall mounting details.
Wall signs attached to exterior walls of solid masonry, concrete or stone shall be safely and securely attached by means of metal anchors, bolts or expansion screws of not less than 9.5 mm (3/8 inch) diameter and shall be embedded not less than 127 mm (5 inches). Wood blocks shall not be used for anchorage, except in the case of wall signs attached to buildings with walls of wood. A wall sign shall not be supported by anchorages secured to an unbraced parapet wall.

E.11.3 Extension.
Wall signs shall not extend above the top of the wall or beyond the ends of the wall to which the signs are attached unless such signs conform to the requirements for roof signs, projecting signs or ground signs.

E.12 PROJECTING SIGNS
E.12.1 General.
Projecting signs shall be constructed entirely of metal or other noncombustible material and securely attached to a building or structure by metal supports such as bolts, anchors, supports, chains, guys or steel rods. Staples or nails shall not be used to secure any projecting sign to any building or structure. The dead load of projecting signs not parallel to the building or structure and the load due to wind pressure shall be supported with chains, guys or steel rods having net cross-clausal dimension of not less than 9.5 mm (3/8 inch) diameter. Such supports shall be erected or maintained at an angle of not less than 45 percent (0.78 rad) with the horizontal to resist the dead load and at angle of 45 percent (0.78 rad) or more with the face of the sign to resist the specified wind pressure. If such projecting sign exceeds 2.8 m² (30 square feet) in one facial area, there shall be provided not fewer than two such supports on each side not more than 2438 mm (8 feet) apart to resist the wind pressure.

E.12.2 Attachment of supports.
Supports shall be secured to a bolt or expansion screw that will develop the strength of the supporting chains, guys or steel rods, with a minimum 15.9 mm (5/8 inch) bolt or lag...
screw, by an expansion shield. Turnbuckles shall be placed in chains, guys or steel rods supporting projecting signs.

E.12.3 Wall mounting details.
Chains, cables, guys or steel rods used to support the live or dead load of projecting signs are permitted to be fastened to solid masonry walls with expansion bolts or by machine screws in iron supports, but such supports shall not be attached to an unbraced parapet wall. Where the supports must be fastened to walls made of wood, the supporting anchor bolts must go through the wall and be plated or fastened on the inside in a secure manner.

E.12.4 Height limitation.
A projecting sign shall not be erected on the wall of any building so as to project above the roof or cornice wall or, on buildings without a cornice wall, above the roof level except that a sign erected at a right angle to the building, the horizontal width of which sign is perpendicular to such a wall and does not exceed 457 mm (18 inches), is permitted to be erected to a height not exceeding 610 mm (2 feet) above the roof or cornice wall or above the roof level where there is no cornice wall. A sign attached to a corner of a building and parallel to the vertical line of such corner shall be deemed to be erected at a right angle to the building wall.

E.12.5 Additional loads.
Projecting sign structures that will be used to support an individual on a ladder or other servicing device, whether or not specifically designed for the servicing device, shall be capable of supporting the anticipated additional load, but not less than a 445 N (100-pound) concentrated horizontal load and a 1334 N (300-pound) concentrated vertical load applied at the point of assumed or most eccentric loading. The building component to which the projecting sign is attached shall be designed to support the additional loads.

E.13 MARQUEE SIGNS

E.13.1 Materials.
Marquee signs shall be constructed entirely of metal or other approved noncombustible material except as provided for in Clauses E.6.1.1 and E.7.1.

E.13.2 Attachment.
Marquee signs shall be attached to approved marquees that are constructed in accordance with Clause 32.6.

E.13.3 Dimensions.
Marquee signs, whether on the front or side, shall not project beyond the perimeter of the marquee.

E.13.4 Height limitation.
Marquee signs shall not extend more than 1829 mm (6 feet) above, or 305 mm (1 foot) below such marquee. Signs shall not have a vertical dimension greater than 2438 mm (8 feet)

E.14 PORTABLE SIGNS

E.14.1 General.
Portable signs shall conform to requirements for ground, roof, projecting, flat and temporary signs where such signs are used in a similar capacity. The requirements of this clause shall not be construed to require portable signs to have connections to surfaces, tie-downs or foundations where provisions are made by temporary means or configuration of the structure to provide stability for the expected duration of the installation.

E.15 REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D635-10</td>
<td>Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position</td>
</tr>
<tr>
<td>GS 1009</td>
<td>Electrical Wiring Code</td>
</tr>
<tr>
<td>ASTM E119</td>
<td>Methods of Fire Test for Flame Propagation</td>
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</tbody>
</table>

TABLE 4-A SIZE, THICKNESS AND TYPE OF GLASS PANELS IN SIGNS

<table>
<thead>
<tr>
<th>MAXIMUM SIZE OF EXPOSED PANEL</th>
<th>MINIMUM THICKNESS OF GLASS (inches)</th>
<th>TYPE OF GLASS</th>
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<tr>
<td>Any dimension (inches)</td>
<td>Area (square inches)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>500</td>
<td>1/8 Plain, plate or wired</td>
</tr>
<tr>
<td>45</td>
<td>700</td>
<td>3/16 Plain, plate or wired</td>
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</table>

1304
**TABLE 4-B**

**THICKNESS OF PROJECTION SIGN**

<table>
<thead>
<tr>
<th>PROJECTION (feet)</th>
<th>MAXIMUM THICKNESS (feet)</th>
</tr>
</thead>
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<tr>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
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</tr>
<tr>
<td>2</td>
<td>3.5</td>
</tr>
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<td>1</td>
<td>4</td>
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</tbody>
</table>

**Note:** For SI: 1 foot = 304.8 mm.

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**APPENDIX F: PATIO COVERS**

**User notes:**
About this appendix: Appendix I provides standards applicable to the construction and use of patio covers. It is limited in application to patio covers accessory to dwelling units. Covers of patios and other outdoor areas associated with restaurants, mercantile buildings, offices, nursing homes or other nondwelling occupancies would be subject to standards in the main Code and not this appendix.

**F.1 GENERAL**

**F.1.1 General.**
Patio covers shall be permitted to be detached from or attached to dwelling units. Patio covers shall be used only for recreational, outdoor living purposes.

---

**F.2 DEFINITION**

**F.2.1 General.**
The following term shall, for the purposes of this appendix, have the meaning shown herein. Refer to Part 2 of this Code for general definitions.

**PATIO COVER.** A structure with open or glazed walls that is used for recreational, outdoor living purposes associated with a dwelling unit.

---

**F.3 EXTERIOR WALLS AND OPENINGS**

**F.3.1 Enclosure walls.**
Enclosure walls shall be permitted to be of any configuration, provided that the open or glazed area of the longer wall and one additional wall is equal to not less than 65 percent of the area below not less than 6 feet 2032 mm (8 inches) of each wall, measured from the floor. Openings shall be permitted to be enclosed with insect screening, translucent or transparent plastic conforming to the provisions of this Code, glass conforming to...
the provisions of Part 25 or any combination of the foregoing.

F.3.2 Light, ventilation and emergency escape.
Exterior openings of the dwelling unit required for light and ventilation shall be permitted to open into a patio structure. However, the patio structure shall be unenclosed if such openings are serving as emergency egress or rescue openings from sleeping rooms. Where such exterior openings serve as an exit from the dwelling unit, the patio structure, unless unenclosed, shall be provided with exits conforming to the provisions of Part 14.

F.4 HEIGHT

F.4.1 Height.
Patio covers shall be limited to one-storey structures not more than 3657 mm (12 feet) in height.

F.5 STRUCTURAL PROVISIONS

F.5.1 Design loads.
Patio covers shall be designed and constructed to sustain, within the stress limits of this Code, all dead loads plus a minimum vertical live load of 0.48 kN/m² (10 pounds per square foot) except that snow loads shall be used where such snow loads exceed this minimum. Such patio covers shall be designed to resist the minimum wind and seismic loads set forth in this Code.

F.5.2 Footings.
In areas with a frost depth of zero, a patio cover shall be permitted to be supported on a concrete slab on grade without footings, provided that the slab conforms to the provisions of Part 20 of this Code and is not less than 89 mm (3 1/2 inches) thick, and the columns do not support loads in excess of 3.36 kN (750 pounds) per column.

APPENDIX G: GROUND GRADING

User notes:
About this appendix: Appendix J provides standards for the properties. The appendix also provides standards for the administration and enforcement of a grading program, including permit and inspection requirements.

G1.1 GENERAL

G1.1.1 Scope.
The provisions of this part apply to grading, excavation and earthwork construction, including fills and embankments.

G1.1.2 Flood hazard areas.
Unless the applicant has submitted an engineering analysis, prepared in accordance with standard engineering practice by a registered design professional, that demonstrates the proposed work will not result in any increase in the level of the base flood, grading, excavation and earthwork construction, including fills and embankments, shall not be permitted in floodways that are in flood hazard areas established or in flood hazard areas where design flood elevations are specified but floodways have not been designated.

G1.2 DEFINITIONS
G1.2.1 Definitions.
The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Part 2 of this Code for general definitions.

BENCH. A relatively level step excavated into earth material on which fill is to be placed.

COMPACTION. The densification of a fill by mechanical means.
DOWN DRAIN. A device for collecting water from a swale or ditch located on or above a slope, and safely delivering it to an approved drainage facility.

EROSION. The wearing away of the ground surface as a result of the movement of wind or water.

EXCAVATION. The removal of earth material by artificial means, also referred to as a cut.

FILL. Deposition of earth materials by artificial means.

GRADE. The vertical location of the ground surface.

GRADE, EXISTING. The grade prior to grading.

GRADE, FINISHED. The grade of the site at the conclusion of all grading efforts.

GRADING. An excavation or fill or combination thereof.

SLOPE. An inclined surface, the inclination of which is expressed as a ratio of vertical distance to horizontal distance.

TERRACE. A relatively level step constructed in the face of a graded slope for drainage and maintenance purposes.

G1.3 PERMITS REQUIRED

G1.3.1 Permits required. Except as exempted in Clause G1.3.2, grading shall not be performed without first having obtained a permit therefore from the head of the works department. A grading permit does not include the construction of retaining walls or other structures.

G1.3.2 Exemptions. A grading permit shall not be required for the following:

1. Grading in an isolated, self-contained area, provided that the public is not endangered and that such grading will not adversely affect adjoining properties.

2. Excavation for construction of a structure permitted under this Code.

3. Cemetery graves.

4. Refuse disposal sites controlled by other regulations.

5. Excavations for wells, or trenches for utilities.

6. Mining, quarrying, excavating, processing or stockpiling rock, sand, gravel, aggregate or clay controlled by other regulations, provided that such operations do not affect the lateral support of, or significantly increase stresses in, soil on adjoining properties.

7. Exploratory excavations performed under the direction of a registered design professional.

Exemption from the permit requirements of this appendix shall not be deemed to grant authorization for any work to be done in any manner in violation of the provisions of this Code or any other legislation.

G1.4 PERMIT APPLICATION AND SUBMISSIONS

G1.4.1 Submission Requirements. In addition to the provisions of Clause 1.9.3, the applicant shall state the estimated quantities of excavation and fill.

G1.4.2 Site plan requirements. In addition to the provisions of Clause 1.9, a grading plan shall show the existing grade and finished grade in contour intervals of sufficient
clarity to indicate the nature and extent of the work and show in detail that it complies with the requirements of this Code. The plans shall show the existing grade on adjoining properties in sufficient detail to identify how grade changes will conform to the requirements of this Code.

G1.4.3 Geotechnical report.
A geotechnical report prepared by a registered design professional shall be provided. The report shall contain not less than the following:

1. The nature and distribution of existing soils.

2. Conclusions and recommendations for grading procedures.

3. Soil design criteria for any structures or embankments required to accomplish the proposed grading.

4. Where necessary, slope stability studies, and recommendations and conclusions regarding site geology.

Exception: A geotechnical report is not required where the head of the works department determines that the nature of the work applied for is such that a report is not necessary.

G1.4.4 Liquefaction study.
For sites with mapped maximum considered earthquake spectral response accelerations at short periods (S) greater than 0.5g as determined by this Code, a study of the liquefaction potential of the site shall be provided and the recommendations incorporated in the plans.

Exception: A liquefaction study is not required where the head of the works department determines from established local data that the liquefaction potential is low.

G1.5 INSPECTIONS

G1.5.1 General.
Inspections shall be governed by Clause 1.12 of this Code.

G1.5.2 Special inspections.
The special inspection requirements of Clause 19.5.6 shall apply to work performed under a grading permit where required by the head of the works department.

G1.6 EXCAVATIONS
G1.6.1 Maximum slope.
The slope of cut surfaces shall not be steeper than is safe for the intended use, and shall be not more than one unit vertical in two units horizontal (50-percent slope) unless the owner or the owner’s authorized agent furnishes a geotechnical report justifying a steeper slope.

Exceptions:

1. A cut surface shall be permitted to be at a slope of 1.5 units horizontal to one unit vertical (67-percent slope) provided that all of the following are met:

   1.1. It is not intended to support structures or surcharges.

   1.2. It is adequately protected against erosion.

   1.3. It is not more than 2438 mm (8 feet) in height.

   1.4. It is approved by the building Code official.

   1.5. Ground water is not encountered.

2. A cut surface in bedrock shall be permitted to be at a slope of one unit horizontal to one unit vertical (100-percent slope).

G1.7 FILLS
G1.7.1 General.
Unless otherwise recommended in the geotechnical report, fills shall comply with the provisions of this clause.
G1.7.2 Surface preparation.
The ground surface shall be prepared to receive fill by removing vegetation, topsoil and other unsuitable materials, and scarifying the ground to provide a bond with the fill material.

G1.7.3 Benching.
Where existing grade is at a slope steeper than one unit vertical in five units horizontal (20-percent slope) and the depth of the fill exceeds 1524 mm (5 feet) benching shall be provided in accordance with Figure J1.7.3. A key shall be provided that is not less than 3048 mm (10 feet) in width and 610 mm (2 feet) in depth.

G1.7.4 Fill material.
Fill material shall not include organic or other deleterious materials. Rock or similar irreducible material greater than 305 mm (12 inches) in any dimension shall not be included in fills.

G1.7.5 Compaction.
All fill material shall be compacted to 90 percent of maximum dry density as determined by ASTM D1557, Modified Proctor, in lifts not exceeding 200 mm (8 inches) in depth.

G1.7.6 Maximum slope.
The slope of fill surfaces shall be not steeper than is safe for the intended use. Fill slopes steeper than one unit vertical in two units horizontal (50-percent slope) shall be justified by a geotechnical report or engineering data.

G1.8 SETBACKS
G1.8.1 General.
Cut and fill slopes shall be set back from the property lines in accordance with this clause. Setback dimensions shall be measured perpendicular to the property line and shall be as shown in Figure G1.8.1, unless substantiating data is submitted justifying reduced setbacks.
Note: For SI: 1 foot = 304.8 mm.

**FIGURE G1.8.1**

**DRAINAGE DIMENSIONS**

G1.8.2 Top of slope.

The setback at the top of a cut slope shall be not less than that shown in Figure J108.1, or than is required to accommodate any required interceptor drains, whichever is greater.

G1.8.3 Slope protection.

Where required to protect adjacent properties at the toe of a slope from adverse effects of the grading, additional protection, approved by the head of the works department, shall be included. Such protection shall include but not limited to:

1. Setbacks greater than those required by Figure G1.8.1.

2. Provisions for retaining walls or similar construction.

3. Erosion protection of the fill slopes.

4. Provision for the control of surface waters.

**G1.9 DRAINAGE AND TERRACING**

G1.9.1 General.

Unless otherwise recommended by a registered design professional, drainage facilities and terracing shall be provided in accordance with the requirements of this clause.

**Exception:** Drainage facilities and terracing need not be provided where the ground slope is not steeper than one unit vertical in three units horizontal (33-percent slope).

G1.9.2 Terraces.

Terraces not less than 1829 mm (6 feet) in width shall be established at not more than 9144 mm (30-foot) vertical intervals on all cut or fill slopes to control surface drainage and debris. Suitable access shall be provided to allow for cleaning and maintenance.

Where more than two terraces are required, one terrace, located at approximately mid-height, shall be not less than 3658 mm (12 feet) in width.
Swales or ditches shall be provided on terraces. They shall have a minimum gradient of one unit vertical in 20 units horizontal (5-percent slope) and shall be paved with concrete not less than 3 inches (76 mm) in thickness, or with other materials suitable to the application. They shall have a depth not less than 305 mm (12 inches) and a width not less than 1524 mm (5 feet).

A single run of swale or ditch shall not collect runoff from a tributary area exceeding 1256 m² (13,500 square feet) (projected) without discharging into a down drain.

G1.9.3 Interceptor drains.
Interceptor drains shall be installed along the top of cut slopes receiving drainage from a tributary width greater than 12 192 mm (40 feet), measured horizontally. They shall have a minimum depth of 305 mm (1 foot) and a minimum width of 915 mm (3 feet). The slope shall be approved by the head of the works department, but shall be not less than one unit vertical in 50 units horizontal (2-percent slope). The drain shall be paved with concrete not less than 76 mm (3 inches) in thickness, or by other materials suitable to the application. Discharge from the drain shall be accomplished in a manner to prevent erosion and shall be approved by the head of the works department.

G1.9.4 Drainage across property lines.
Drainage across property lines shall not exceed that which existed prior to grading. Excess or concentrated drainage shall be contained on site or directed to an approved drainage facility. Erosion of the ground in the area of discharge shall be prevented by installation of nonerosive down drains or other devices.

G1.10 EROSION CONTROL
G1.10.1 General.
The faces of cut and fill slopes shall be prepared and maintained to control erosion. This control shall be permitted to consist of effective planting.

Exception: Erosion control measures need not be provided on cut slopes not subject to erosion due to the erosion-resistant character of the materials.

Erosion control for the slopes shall be installed as soon as practicable and prior to calling for final inspection.

G1.10.2 Other devices.
Where necessary, check dams, cribbing, riprap or other devices or methods shall be employed to control erosion and provide safety.

G1.11 REFERENCED STANDARDS

ASTM D1557-12 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort [2,700 kN-m/m³ (56,000 ft-lb/ft³)].
H1.1.1 General.

Every structure located where the 1-second spectral response acceleration, $S_1$, determined in accordance with this Code, is greater than 0.40 and either exceeds six stories in height with an aggregate floor area of $5574 \text{ m}^2 (60,000 \text{ square feet})$ or more, or exceeds 10 stories in height regardless of floor area, shall be equipped with not fewer than three approved recording seismographs. The seismograph shall be interconnected for common start and common timing.

H1.1.2 Location.

As a minimum, instruments shall be located at the lowest level, mid-height, and near the top of the structure. Each instrument shall be located so that access is maintained at all times and is unobstructed by room contents. A sign stating “MAINTAIN CLEAR ACCESS TO THIS INSTRUMENT” in 25 mm (1-inch) block letters shall be posted in a conspicuous location.

H1.1.3 Maintenance.

Maintenance and service of the instruments shall be performed annually by an approved testing agency. The owner shall file with the geological survey department on request a written report from an approved testing agency certifying that each instrument has been serviced and is in proper working condition. This report shall be submitted when the instruments are installed and annually thereafter. Each instrument shall have affixed to it an externally visible tag specifying the date of the last maintenance or service and the printed name and address of the testing agency.

Maintenance and service of the instrumentation shall be provided by the owner of the structure. Data produced by the instrument shall be made available to the geological survey department on request.

I. Zone identification (horizontal and vertical).
2. Foundation design for erosion and scour.
3. Storm loading (including wind, waves, hydrostatic, and hydrodynamic loads).

I.1 CLAUSE I.2 CODE DEFINITIONS

The following definitions are recommended for inclusion within the coastal building Code, in order to clarify the coastal engineering and construction terminology adopted.

BEACH: The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. Unless otherwise specified, the seaward limit of a beach is the mean low water line. Beach is alternatively termed the “shore.”

BREAK-AWAY WALL OR FRANGIBLE WALL: A partition independent of supporting structural members that will withstand design wind forces but will fail under hydrostatic, wave and runup forces associated with the design storm surge. Under such conditions, the wall should fail in such a manner that it dissolves or breaks up into components that will not act as potentially damaging missiles.

COASTAL AND SHORE PROTECTION STRUCTURES: Shore hardening structures, such as seawalls, bulkheads, revetments, rubble mound structures; groins and breakwaters; aggregates of materials other than beach sand used for shoreline protection; beach and dune restoration; and other structures which are intended to prevent erosion or protect other structures from wave and hydrodynamic forces. Coastal protection structures are intended for the protection of upland properties and structures, whereas, shore protection structures are intended for the protection of the beach or shoreline.

COLUMN ACTION: The elastic instability in piles or columns resulting from stresses due to axial and/or lateral loads.

DUNE: A mound or ridge of loose sediment, usually sand-sized, lying upland of the beach or shore, and deposited by any natural or artificial mechanism (e.g., a dune may also include a beach ridge, dune ridge, chenier, etc.).
EROSION: The wearing away of land or the removal of beach or dune material by wave action, tidal currents or deflation. Erosion includes but is not limited to:

(a) Horizontal recession, which is where the storm surge intersects but does not inundate the profile and where horizontal littoral activity due to waves, currents and runup erodes the profile.

(b) Scour, which is where the topography is completely inundated by the storm surge, and where wave and current forces erode the profile in the vertical direction.

EXCAVATION: Any mechanical removal of rock or unconsolidated material.

HYDRODYNAMIC LOADS: Those forces resulting from a mass of water in motion, e.g., the flow accompanying a storm surge. Hydrodynamic loads are generally lateral forces, but also include effects of the turbulence resulting from the interaction of the flowing water mass with a rigid structure. Hydrodynamic load computations for construction consider all predominant forcing functions responsible for the motion of the aquatic mass, which are the astronomical tide and the storm waves (including the orbital particle transport, longshore mass transport, and shore-normal mass transport), as well as the storm surge. Gravity and forced flow resulting from the inundation accompanying the storm surge of a 1 DO-year storm event are considered. Hydrodynamic load computations consider the processes of mass transport, heat transport, and momentum transport, along with the corresponding natural laws which are the conservation of matter, the conservation of energy (first law of thermodynamics), and Newton's second law (the equation of motion). Hydrodynamic load computations also consider the various flow forms including forms referring to spatial variation (uniform and non-uniform flow), forms referring to variation in time (steady, quasi-steady, and non-steady flow), forms referring to the nature of flow (laminar and turbulent flow), and forms referring to the type of flow energy (subcritical, critical, and supercritical flow). In addition, hydrodynamic load computations include the transformation of flow energy form from supercritical flow to subcritical flow, and vice versa, including all classifications of hydraulic jump. Hydrodynamic load computations consider hydraulic flow across both a fixed bed and a movable bed where applicable.

HYDROSTATIC LOADS: Those lateral and vertical (including uplift) forces resulting from a mass of water standing either above or below the soil surface. These loads are equal to the product of the water pressure at the centroid of the plane surface area on which the pressure acts times the area of that surface. The hydrostatic pressure is equal to the product of the unit weight of the water times the elevation of the water above the point of measurement. Hydrostatic loads which are confined may be determined using the elevation to which the confined water would freely rise if unconfined. Hydrostatic pressures at any point are equal in all directions and act normal to the applied surface and are passive in nature.

INUNDATE: To cover or overflow as with a flood.

MAJOR STRUCTURES: Houses, mobile homes, apartment buildings, condominiums, motels, hotels, restaurants, other types of residential or commercial buildings, towers, swimming pools, piers, pipelines, and other projects having the potential for substantial impact on the beach and dune systems. Major structures include any structure which is neither a "minor structure" nor a "coastal or shore protection structure."

MINOR STRUCTURES: Elevated dune and beach walkover structures, beach access ramps and walkways, stairways, pile-supported elevated viewing platforms, gazebos, boardwalks, lifeguard support structures, pile supported or cantilevered decks or porches on new or existing structures, slab patios, sidewalks, driveways, and other uncovered paved areas (e.g., parking areas, shuffleboard courts, tennis courts, etc.), earth retaining walls, sand fences, privacy fences, ornamental walls, ornamental garden structures, aviaries, subgrade utilities (e.g., wells, septic tanks, and drain fields) which require material alteration and restoration of topography, and ornamental projects. Usage is not the only criterion used to classify structures as minor. It is a characteristic of minor structures that they are considered to be expendable under wind and wave forces.

ONE-HUNDRED-YEAR STORM: A shore-incident hurricane or any other storm with accompanying wind and wave intensity having a one-percent chance of being equaled or exceeded in any given year during a 100-year interval.
PILE FOUNDATION: A system of piles providing the support of a structure, including those piles terminating below grade at pile caps and those piles extending above grade to superelevate a structure.

STORM SURGE: The rise above normal water level on the open coast due to a number of factors, including the action of wind stress on the water surface and the rise in level due to atmospheric pressure reduction.

UPLIFT PRESSURE: Any upward hydrostatic, hydrodynamic, or wind pressure on the soffit, base, deck or floor of a structure.

WAVE: A ridge, deformation, or undulation of the surface of a liquid. Storm generated ocean waves shore-propagating upon the storm surge are considered for design purposes. The wave forces are dependent upon the type of wave considered (i.e., unbroken, broken or breaking).

I.3 ZONES
A coastal building Code should identify the zone within which major construction should be designed for the physical environmental conditions accompanying a major storm event is the zone of impact of a 100-year storm surge or of a number of lesser storms which cumulatively have an equivalent probability of occurrence. For coastal areas which are predicted to be flooded by the storm surge of a 100-year storm, a zone of impact is identified by the possible existence of breaking waves which are significantly large to cause structural damage. For coastal areas not overtopped by a predictable 100-year storm surge, the impact zone is identified by the wave runup and the erosion limits of that storm or of storms having impact with an equivalent cumulative probability.

Seaward of a coastal construction building zone, a coastal conservation zone should be identified within which no major habitable structures should be erected. The inland limits of this coastal conservation zone would coincide with the seaward limits of the coastal construction building zone and would identify the seaward-most dune and beach area in need of preservation from the impact associated with the construction of major habitable structures. Identification of the line of demarcation between a coastal construction building zone and a coastal conservation zone would have to result from a consideration of the existence and degree of existing development, as well as the predictable beach and dune response to high frequency (less than 20-year) storm events.

For developed coastal areas within which there exists a reasonably continuous line of rigid coastal protection structures, regardless of the design adequacy of these coastal protection structures, such a line should define the seaward limits of the coastal construction building zone. (See the following illustration.)
For developed and undeveloped coastal areas where there does not exist a line of rigid coastal protection structures, the dune system itself should be identified as a flexible coastal protection structure. Although guidance and rationale would vary in different locales, it is suggested that the inland limits of the coastal conservation zone be defined by the dune erosion limits of a 20-year storm event or the dune erosion which would be expected resulting from storms with an equivalent cumulative probability. (See the following illustration.)
Although horizontal zonation, that is identification of the coastal construction building zone and coastal conservation zone, is of primary importance, vertical zonation should be included by identifying the elevation above which major habitable structures should be constructed. The standard adopted is the requirement to elevate the habitable structure such that the structural soffit or the underside of the lowest supporting structural member, excluding the foundation piles, is above the design breaking wave crests or wave uprush as superimposed on the storm surge of a 100-year storm.

I.4 FOUNDATION DESIGN

Foundation design within the coastal construction building zone should consider the topographic changes which may be expected over the design life of the structure. Foundation design should consider the erosion, scour, and loads accompanying a 100-year storm event.

Soil bearing foundations are discouraged within the coastal construction building zone and should be prohibited above the design grade. The elevation of the soil surface to be used in the calculation of bearing capacities should not be higher than that which would result from the erosion of a design storm. Calculation of the design grade should account for localized scour due to the presence of structural components. The maximum elevation of a soil bearing foundation should be set below the design grade resulting from the erosion (including scour) of a 1 DO-year storm event. Erosion computations for foundation design should account for all vertical and lateral erosion and scour producing forces.

All habitable structures within the coastal construction building zone are recommended to be elevated on and securely anchored to an adequate pile foundation. The structure should be anchored in such a manner as to prevent flotation, collapse, or lateral displacement. A pile foundation should be designed to withstand all anticipated loads resulting from a 100-year storm event including wave, hydrostatic, hydrodynamic, and wind loads acting simultaneously with live and dead loads.

Design ratio of pile spacing to pile diameter is not recommended to be less than 8:1 for individual piles; however, this would not apply to pile clusters located below the design grade. Pile caps should be set below the design grade (which includes localized scour), while the piles should be driven to a penetration which achieves adequate bearing capacity taking into consideration the anticipated loss of soil above the design grade.

In addition to normal foundation analysis, pile foundation analysis should consider piles in column action from the bottom of the supported structure to the design grade. Consideration should also be given to the degree of exposure to wave attack and the resulting impact loads on lateral or diagonal bracing between piles. Lateral bracing should be designed to minimize resistance to flow and to the entrapment of floating debris.

Within the coastal construction building zone, substantial walls and partitions constructed below the level of the first finished floor should be prohibited. It is recommended that such a prohibition exempt stairways, utilities, shearwalls perpendicular to breaking waves, wind/sand screens, light open wood lattice partitions, elevator shafts, and breakaway or frangible walls designed to collapse under wave forces. Any construction within the vertical zone of design storm wave impact should be designed in such a manner so as to minimize the release of destructive hydrodynamic missiles.

I.5 STORM LOADS

A coastal building Code should require that all habitable major structures be designed for the loads accompanying a 100-year storm event, including wind, wave, hydrostatic, and hydrodynamic loads. Within the coastal construction building zone and the coastal conservation zone, minor structures need not meet specific structural requirements for wind and wave forces, but they should be designed to minimize the potential for generating aerodynamically or hydrodynamically propelled missiles. Minor structures should also be designed to produce a minimum adverse impact on the beach or dune system.

The wind load requirements of a coastal building Code need to be established considering historical records of storm
generated wind velocities over water in the specific region.

The water related loads accompanying a design coastal incident storm event provide a major area of deficiency in most building Codes, with wind generated waves producing the most analytically complex yet the most critical of forces to which the coast and its structures are subjected. The coastal building Code should require that major habitable structures be designed in consideration of the expected shore-propagating wave conditions upon the surge of a 100-year storm event. Breaking, broken, and non-breaking waves should be considered as applicable. Design wave loading analysis should consider vertical uplift pressures and all lateral pressures to include impact, as well as, dynamic loading and the harmonic intensification resulting from repetitive waves.

In addition to the wind and wave loads, a coastal building Code should require that all major habitable structures be designed for the hydrostatic and hydrodynamic loads which would be expected under the conditions of maximum inundation associated with a 100-year storm event. Calculations for hydrostatic loads should consider the maximum water pressure resulting from a peaked breaking wave superimposed on the storm surge of a 100-year storm event. Both free and confined hydrostatic loads should be considered, while confined hydrostatic loads should be determined using the maximum elevation to which the confined water would freely rise if unconfined.

Vertical hydrostatic loads should be considered as forces acting both vertically downward and upward on horizontal or inclined surfaces of major structures (e.g. floors, slabs, roofs, walls). Lateral hydrostatic loads should be considered as forces acting horizontally above and below grade on vertical or inclined surfaces of major structures and coastal or shore protection structures. Hydrostatic loads on irregular or curving geometric surfaces may be determined in consideration of separate vertical and horizontal components acting simultaneously under the distribution of the hydrostatic pressures.

Calculations for hydrodynamic loads should consider the maximum water pressures resulting from the motion of the water mass associated with a 100-year storm event. A more detailed discussion of these loads may be found in the definitions which follow.

When considering water related loads, specialized loads of importance to the coastal building Code are battering loads. Habitable major structures including the foundation should be designed to resist the battering loads which may reasonably be anticipated resulting from isolated floating or suspended objects during a 100-year storm event.

I.6 EXCAVATIONS
A major consideration of a coastal building Code, excavation is generally not recommended within the coastal construction building zone and should be prohibited within the coastal conservation zone. Any proposed excavation design should consider the coastal topographic changes accompanying a JOO-year storm event and those anticipated topographic changes which have an equivalent probability of occurrence. Upon consideration of these topographic changes, any excavation within the coastal construction building zone which have the potential for a negative impact or would accelerate erosion should be prohibited. Excavation associated with the construction of a major structure within the coastal construction building zone should be limited to that incidental to the construction of the foundation and necessary for utilities. Excavation required for swimming pool construction within the coastal construction building zone should be minimized, located as far inland as possible, and not result in a net loss of sediment in the immediate area. All beach compatible excavated material or an equivalent volume of beach compatible material should be used as fill to be placed generally seaward of the excavation.

I.7 COASTAL AND SHORE PROTECTION STRUCTURES
The coastal building Code should address coastal and shore protection structures as a separate classification for design. In general, the construction or rehabilitation of flexible coastal and shore protection structures such as beach nourishment, dune construction and stabilization, and sand fencing should be encouraged over the construction of rigid coastal and shore protection structures (seawalls, bulkheads, revetments, rubble mounds, groins, etc.) if such beach an dune restoration activity is of acceptable coastal engineering design an is compatible with the existing coastal systems. The construction of isolated rigid coastal or shore protection
structures on undeveloped property is not recommended nor should such structures be designed primarily to protect minor structures.

Seawalls and other rigid coastal protection structures are intended to protect upland structures and property and not to protect the beach. In fact, rigid coastal protection structures usually may be expected to have a long term adverse effect on the adjacent beach. In those instances in which a rigid coastal or shore protection structure is the only feasible means of protecting existing upland structures and property, then that rigid coastal or shore protection structure should be located as far landward as possible, consistent with design and construction requirements. Any seawall or other rigid coastal protection structure should be designed to minimize its erosion impact. Sloping rock revetments, rubble mound structures, and toe-scour protection with rock in front of vertical bulkheads and seawalls are recommended over vertical or sloping solid walls which due to their reflective surface cause substantially greater erosion losses to the adjacent beach.

The major design considerations for coastal and shore protection structures should include structural siting, foundation (e.g. geotextiles), crest (or cap) elevation, toe elevation, structural slope(s), components as impacted by waves superimposed upon the design storm surge, expected scour, impact on the beach and dune system, and impact on the adjacent properties. Coastal and shore protection structures should be designed for the minimum wave loads which are applicable for the design storm conditions which justify the structures. Seawalls, revetments, and rubble mound structures are generally designed for a 20 to 50-year storm event.

The coastal building Code should also address those cases where development is proposed upland of an existing seawall or other rigid coastal protection structure. Such development should be located a sufficient distance upland from the coastal protection structure to allow for the containment of partial failures and to provide adequate room for routine maintenance and future repair to the coastal protection structure. Wave and runoff induced seepage in fill behind coastal protection structures should be considered to avoid partial or complete failure due to piping of fill material under the structures.
APPENDIX J: REPLICABLE BUILDINGS

User notes:
About this appendix: Appendix N provides jurisdictions with a means of incorporating guidelines for replicable buildings into their building Code adoption process. The intent of these provisions is to give jurisdictions a means of streamlining their document review process while verifying Code compliance.

J1.1 ADMINISTRATION
J1.1.1 Purpose.
The purpose of this appendix is to provide a format and direction regarding the implementation of a replicable building program.

J1.1.2 Objectives.
Such programs allow a jurisdiction to recover from a natural disaster faster and allow for consistent application of the Codes for replicable building projects. It will result in faster turnaround for the end user, and a quicker turnaround through the plan review process.

J1.2 DEFINITIONS
J1.2.1 Definitions.
The following words and terms shall, for the purposes of this appendix, have the meanings shown herein.

REPLICABLE BUILDING. A building or structure utilizing a replicable design.

REPLICABLE DESIGN. A prototypical design developed for application in multiple locations with minimal variation or modification.

J1.3 REPLICABLE DESIGN REQUIREMENTS
J1.3.1 Prototypical construction documents.
A replicable design shall establish prototypical construction documents for application at multiple locations. The construction documents shall include details appropriate to each wind region, seismic design category, and climate zone for locations in which the replicable design is intended for application. Application of replicable design shall not vary with regard to the following, except for allowable variations in accordance with Clause J1.6.

1. Use and occupancy classification.
2. Building heights and area limitations.
3. Type of construction classification.
5. Interior finishes.
6. Fire protection system.
8. Accessibility.
9. Structural design criteria.
11. Type of mechanical and electrical systems.
12. Type of plumbing system and number of fixtures.

J1.4 REPLICABLE DESIGN SUBMISSION REQUIREMENTS
J1.4.1 General.
A summary description of the replicable design and related construction documents shall be submitted to the Head of Works Department. Where approval is requested for elements of the replicable design that is not within the scope of this Code, the construction documents shall specifically designate the Codes for which review is sought. Construction documents shall be signed, sealed and dated by a registered design professional.

J1.4.1.1 Architectural plans and specifications.
Where approval of the architectural requirements of the replicable design is sought, the Submission documents shall include architectural plans and specifications as follows:

1. Description of uses and the proposed occupancy groups for all portions of the building.
2. Proposed type of construction of the building.

3. Fully dimensioned drawings to determine building areas and height.

4. Adequate details and dimensions to evaluate means of egress, including occupant loads for each floor, exit arrangement and sizes, corridors, doors and stairs.

5. Exit signs and means of egress lighting, including power supply.

6. Accessibility scoping provisions.

7. Description and details of proposed special occupancies such as a covered mall, high-rise, mezzanine, atrium and public garage.

8. Adequate details to evaluate fire-resistance-rated construction requirements, including data substantiating required ratings.

9. Details for plastics, insulation and safety glazing installation.

10. Details of required fire protection systems.

11. Material specifications demonstrating fire-resistance criteria.

J1.4.2 Structural plans, specifications and engineering details.

Where approval of the structural requirements of the replicable design is sought, the submitted documents shall include details for each wind region, seismic design category for which approval is sought; and shall include the following:

1. Signed and sealed structural design calculations that support the member sizes on the drawings.

2. Design load criteria, including: frost depth, live loads, wind loads, earthquake design date, and other special loads.

3. Details of foundations and superstructure.


J1.4.3 Energy conservation details.

Where approval of the energy conservation requirements of the replicable design is sought, the submitted documents shall include the following:

1. Building envelope details.

2. Building mechanical system details.

3. Details of electrical power and lighting systems.


J1.5 REVIEW AND APPROVAL OF REPLICABLE DESIGN

J1.5.1 General.

Proposed replicable designs shall be reviewed by the Head of Works Department. The review shall be applicable only to the replicable design features submitted in accordance with Clause J1.4. The review shall determine compliance with this Code and additional Codes specified in Clause J1.4.1.

J1.5.2 Documentation.

The results of the review shall be documented indicating compliance with the Code requirements.

J1.5.3 Deficiencies.

Where the review of the submitted construction documents identifies elements where the design is deficient and will not comply with the applicable Code requirements, the Head of Works Department shall notify the
proponent of the replicable design, in writing, of the specific areas of noncompliance and request correction.

**J1.5.4 Approval.**

Where the review of the submitted construction documents determines that the design is in compliance with the Codes designated in Clause J1.4.1, and where deficiencies identified in Clause J1.5.3 have been corrected the Head of Works Department shall issue a summary report of Approved Replicable Design. The summary report shall include any limitations on the approved replicable design including, but not limited to climate zones, wind regions and seismic design categories.

**J1.6 SITE-SPECIFIC APPLICATION OF APPROVED REPLICABLE DESIGN**

**J1.6.1 General.**

Where site-specific application of a replicable design that has been approved under the provisions of Clause J1.5 is sought, the construction documents submitted to the head of the works department shall comply with this clause.

**J1.6.2 Submission documents.**

A summary description of the replicable design and related construction document shall be submitted. Construction documents shall be signed, sealed and dated by the registered design professional. A statement, signed, sealed and dated by the registered design professional, that the replicable design submitted for local review is the same as the replicable design reviewed by the Head of Works Department, shall be submitted.

**J1.6.2.1 Architectural plans and specifications.**

Architectural plans and specifications shall include the following:

1. Construction documents for variations from the replicable design.

2. Construction for portions that are not part of the replicable design.

3. Documents for local requirements as identified by the head of the works department.

4. Construction documents detailing the foundation system.
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GS 1119- 2016 Accessibility Standard for the Built Environment


Version 1.1, July 2007, Section 18-Concrete Works.

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