FIRE RESISTANCE

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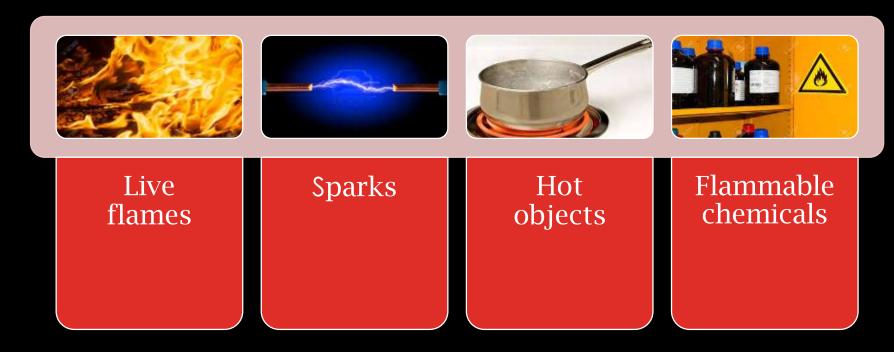
FIRE HAZARDS IN BUILDINGS



FIRE HAZARDS

• Fire hazards are hazards that involve the presence of flame or the risk of an uncontrolled fire.

• FIRE HAZARDS include:



FIRE HAZARDS AT WORKPLACE

- Open flames used in various applications (such as welding)
- Electric wires, higher loads, loose connections, and old electrical equipment
- All cooking and heat generating appliances
- Smoking and the use of personal lighters or matches
- Improper or unauthorized stowage of flammable and hazardous materials and chemicals
- Insufficient capacity and numbers of emergency exits and stairs
- Hindrance to sight or reach firefighting equipment, markings, and alarm systems
- Insufficient numbers and types of fire extinguishers
- Absence of fire detection and alarm system
- Violation of building and fire codes

FIRE HAZARDS AT HOME

- Candles near inflammable materials, not on proper holder.
- Fire during cooking:
 - If objects near to stove catch fire
 - Dirty ovens/stones : accumulated grease
 - Clothes catching fire during cooking
 - Gas leakage
- Electrical fire:
 - Defects in electrical appliances
 - Loose wiring and circuits
 - Improper earthing of wires
 - Overloading
 - Loose electrical plugs
 - Keeping appliances turned on for a long time period

FIRE HAZARDS AT HOME

- Wrong handling of matches and lighters near combustible materials
- Smoking:
 - Smoking inside the building
 - Wrong disposal of cigarettes
 - Incomplete extinguishing of ciggarates

CLASSIFICATION OF BUILDINGS ACCORDING TO FIRE RESISTANCE

FIRE RESISTANCE OF BUILDINGS

- Selection of materials for different components of a building is the most important factor to prevent fire spreading, burn out ad loss of life and property.
- Fire resistance of a building or its elements is expressed in hours against a specific test load (K cal/ m^2) and against a certain intensity of fire

(IS 3808, 3809: 1979)

CLASSIFICATION OF BUILDINGS

TYPE I

 When all structural components have 4 hours fire resistance

TYPE II

 When all structural components have 3 hours fire resistance

TYPE III

 When all structural components have 2 hours fire resistance

TYPE IV

When all structural components have 1 hours fire resistance

Table 1 Fire Resistance Ratings of Structural and Non-Structural Elements (Hours)

(Clause 3.3.1)

SI			Structural Element		Type of C	onstruction	
No.				Type 1	Type 2	Type 3	Type 4
. (1)			(2)	(3)	(4)	(5)	(6)
i)	Exterior walls:						
	a) Fire separation less than 3.7 m	a.)	Bearing	4	. 2	2	1
		b)	Non-bearing	2	195	1	1
	 Fire separation of 3.7 m or more 	\mathbf{a})	Bearing	4	2	2	1
	but less than 9 m	b)	Non-bearing	11/2	1	1	1
	 Fire separation of 9 m or more 	\mathbf{a})	Bearing	4	2	2	1
		b)	Non-bearing	1	1	1	1
ii)	Fire resisting walls		•	4	2	2	2
iii)	Fire separation assemblies (like fire check doors)			4	2	2	2
iv)	Fire enclosures of exitways, hallways and stairways			2	, 2	2	2
v)	Shaft other than exitways, elevator and hoistways			2	2	2	2
vi)	Exitway access corridors			1	2° 1	1	1
viii)	Vertical separation of tenant spaces			1 .	1	1	1
viiii)	Dwelling unit separation			1	1	. 1	1
_	Non-load bearing partitions				At least	half an hour -	
ix)	Interior bearing walls, bearing	a)	Supporting more than one floor	4	2	2	2
	partitions, columns, girders, trusses	b)	Supporting one floor only	3	11/2	1	1
	(other than roof trusses) and framing	c)	Supporting a roof only	3	11/2	1	1
X)	Structural members support walls			3	11/2	1	1
xi)	Floor construction including walls			3	11/2	. 1	1
xii)	Roof construction	a)	5 m or less in height to lowest member	2	11/2	1	1
		b)	More than 5 m but less than 6.7 m in height to lowest member	1	1	1	1
		c)	6.7 m or more in height to lowest member	0	o	0	0

FIRE RESISTING PROPERTIES OF BUILDING MATERIALS

FIRE RESISTING PROPERTIES OF BUILDING MATERIALS



- · 1st class bricks are highly fire resistant as they are subjected to heat and temperature during manufacturing.
- Brick masonry most suitable for guarding against fire for a considerable time



- · Most unsuitable for fire protection
- · Limestone can crumble to powder during fire
- Sedimentary types of stones can expand, crack and get broken into pieces.
- Granite can explode and disintegrate when exposed to high heat

Table 2 Masonry Walls: Solid (Required to Resist Fire from One Side at a Time)

(Clause 3,3.2)

SI No.	Nature of Construction and Materials		M	inimum		ess (mm), Resistan			Finish fo	**	
		_	L	ad Bear	ing			Non	-load Be	aring	
		1	135	2	3	4	1	196	2	3	4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ij	Reinforced ¹¹ cement concrete	120 (25) ²¹	140 (25) ²⁾	160 (25) ²⁾	200 (25) ²¹	240 (25) ²⁾					
ii)	Unreinforced cement concrete	150	175	-	1000						
(11)	No-fines concrete with :										
	a) 13 mm centent/sand or gypsum/sand	_	-	_	-	-	150	150	150	150	150
	 b) 13 mm light weight aggregate gypsum plaster 	-	-	-	-	-	150	150	150	150	150
iv)	Bricks of clay:		73323	09.95	98384	107.000	1021		1025	183200	20.000
	a) Without finish	90	100	100	170	170	75	90	100	170	170
	 b) With 13 mm lightweight aggregate gypsum plaster 	90	90	90	100	100	75	90	90	90	100
٧)	Bricks of sand lime:	00		1110	1	27		722	144	4	- 40
	a) Without finish	90	100	100	190	190	75	90	100	170	170
	 b) With 13 mm lightweight aggregate gypoum plaster 	90	90	90	100	100	75	90	90	90	100
VI)	Blocks of concrete:	2.21	10000	17.630			027	2000	2000	12.2211	1022
	a) Without finish	90	100	100		77.	75	90	100	140	150
	 b) With 13 mm lightweight aggregate gypsum plaster 	90	90	90	100	100	75	75	75	90	100
	 with 13 mm cement/sand or gypsum/ sand 						75	90	90	100	140
vii)	Blocks of lightweight concrete:										
	a) Without finish	90	100	100	140	150	75	75	75	125	140
	b) With 13 mm lightweight aggregate gypsum plaster	90	90	90	100	100	50	63	75	75	75
	 e) With 13 mm cement/sand or gypsum/ sand 	-	100	-	100	-	75	75	75	90	100
viii)	Blocks of seruted concrete:					0.00		10.92			
	a) Without finish	90	100	100	140	180	50	63	63	75	100
	With 13 mm lightweight aggregate gypsum plaster	90	90	100	100	150					

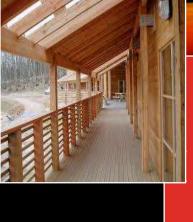
¹³ Walls containing at least 1 percent of vertical reinforcement.

Table 3 Masonry Walls: Hollow (Required to Resist Fire from One Side at a Time)

(Clause 3.3.2)

SI No.	Nature of Construction and Materials		Ŋ	Gnimu			om), Ex stance (1377/12/7	any Flo of	nish for	,	
		_	Lo	ad Bear	ing		$\hat{}$		Non-loa	d Behrin	ŧ	
		T	11/2	1	3	4	14	1	11/1	2	3	7
(l)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1)	Bricks of clay: a) Without finish b) With 13 mm lightweight aggregate gypsum plaster	170 100	170 100	170 170	200 170	200 170	75 75	75 75	90 90	100 90	170 90	170
ii)	Blocks of concrete: a) Without finish b) With 13 mm cement/sand or gypsum/sand c) With 13 mm lightweight aggregate gypsum plaster	190	200	200	-	-	90 90 75	125 125 90	125 125 90	140 140 100	140 140 125	150 140 125
iii)	Blocks of lightweight concrete: a) Without finish b) With 13 mm cement/sand or gypsum/sand c) With 13 mm lightweight aggregate gypsum plaster	100	100	100	1 1 1	-	75 75 63	90 75 63	90 75 63	100 100 75	140 140 90	150 140 100

²⁾ Minimum thickness of actual cover to reinforcement.



Prone to fire attack

Sharp edges and thin pieces of timber may catch fire easily than round corners and heavy sections.

- Fire retarding chemicals (ammonium phosphate and sulphate, boric acid and borax, zinc chloride) impregnated into pores of timber before use in building to retard increase in temperature during fire.
 - · 32-48 kg chemicals per m3 of timber for moderate control
 - · 80-100 kg chemicals per m3 of timber for moderate control
- Fire resistant paints can also be used on timber elements (Asbestos paints, magnesium sulphate, ferrous oxide paints)





- · Steel is fire resistive to a certain extent.
- · With rise of temperature, strength of steel fails greatly causing failure and collapse of structures and it elements.
- · Steel protected with heat insulation materials (like bricks, concrete, asbestos etc.) to protect structure from failure.
- · During extinguishing fires, when water in sprinkled on steel, it may twist and distort.



- · Concrete made from brick, cinder, clinker, slag is more fire resistive than that made with igneous rock ballast which cracks on exposure of high heat.
- Thickness of clear cover should be more to increase fire resistance of concrete.



· Steel is fire resistive to a certain extent.

- · With rise of temperature, strength of steel fails greatly causing failure and collapse of structures and it elements.
- · Steel protected with heat insulation materials (like bricks, concrete, asbestos etc.) to protect structure from failure.
- · During extinguishing fires, when water in sprinkled on steel, it may twist and distort.

Table 10 Reinforced Concrete Columns

(Clause 3.3.2)

Sl No.	Nature of Constru	ction and Materials	Minimum Dimensions (mm) Excluding any Finish, for a Fire Resistance of					
			14 h	1 h	1½ h	2 h	3 h	4h
(1)	C	2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Fully exposed	Width Cover	150 40	200 40	250 40	300 40	400 40	450 40
ii)	50 percent exposed	Width Cover	125 40	160 40	200	200 40	300 40	350 40
iii)	One face exposed	Thickness Cover	100 40	120 40	140 40	160 40	200 40	240 40

Table 11 Concrete Beams

(Clause 3.3.2)

SI No.	Nature of Construction and Materials	1	Minimum Dimensions (mm) Excluding any Finish, for a Fire Resistance of							
			1/2 h	1 h	11/2 h	2 h	3 h	4 h		
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)		
i)	Reinforced concrete (simply supported)	Width	200	200	200	200	240	280		
		Cover	20	20	20	40	60 ¹⁾	70 ^{t)}		
ii)	Reinforced concrete (continuous)	Width	200	200	200	200	240	280		
	,	Cover	20	20	20	30	40	50 ¹⁾		
iii)	Prestressed concrete (simply supported)	Width	100	120	150	200	240	280		
		Cover	25	40	55	70	80	90		
iv)	Prestressed concrete (continuous)	Width	80	100	120	150	200	240		
,	,,	Cover	20	30	40	55	70	80		

¹¹ Require attention to the additional measures necessary to reduce the risk of spalling.

Table 12 Concrete Floors

(Clause 3.3.2)

SI No.	Nature of Construction and Materials		Min		ensions (mm er a Fire Re	-	W T	sh,
			1/2 h	lh	1½ h	2 h	3 h	4h
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)
i)	Reinforced concrete (simply supported)	Thickness Cover	75 20	95 20	110 25	125 35	150 45 ⁽⁾	170 55 ¹⁾
ii)	Reinforced concrete (continuous)	Thickness Cover	75 20	95 20	110 20	125 25	150 35	170 45 ^{t)}

¹⁾ Require attention to the additional measures necessary to reduce the risk of spalling.



- · Good fire resistance.
- · Low coefficient of thermal expansion and high fire resistive property.
- Used to cover structural components



- Bad conductor of heat and has low coefficient of thermal expansion. Sudden change in temperature can cause temporary cracks on it.
- · Used in glazing
- Used in fire resisting of doors, windows, sky-lights and lanterns.

REQUIREMENTS IN BUILDINGS FOR FIRE RESISTANCE

REQUIREMENTS IN BUILDINGS FOR SAFETY OF LIFE FROM FIRE, SMOKE, FUMES AS PER NBC

• **MAXIMUM HEIGHT**: (3.4.4)

Every building shall be restricted in its height above the ground level and the number of storeys, depending upon its occupancy and the type of construction. The maximum permissible height for any combination of occupancy and types of construction should necessarily be related to the width of street fronting the building, or floor area ratios and The local fire fighting facilities available.

• MAXIMUM FLOOR AREA RATIO: (3.4.5)

Table 19 Comparative Floor Area Ratios for Occupancies Facing One Public Street Atleast 9 m Wide

(Clauses 2.6 and 3.4.5)

Occupancy Classification	Type of Construction						
Ciasalikation	Type 1	Type 2	Type 3	Type 4			
(1)	(2)	(3)	(4)	(5)			
Residential	UL	2.0	1.4	1.0			
Educational	UL	2.0	1.4	1.0			
Institutional	UL	1.5	1.0	0.8			
Assembly	UL	1.0	0.7	0.5			
Business	UL	2.9	2.3	1.6			
Mercantile	8.0	1.8	1.4	1.0			
Industrial	7.5	1.9	1.6	1.3			
Storage (see Note 5)	6.0	1.5	1.3	1.0			
Hazardous (see Note 5)	2.8	1.1	0.9	NP			

UL — Unlimited.

NP - Not permitted.

NOTES

- 1 The FAR values given in this table are subject to overall restrictions on the heights of buildings in the case of educational, institutional, assembly, storage and hazardous occupancies as specified in col 2 of Table 23.
- 2 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.
- 3 This table should be modified by the Authority, taking into account the other aspects as given below:
 - a) Density in terms of dwelling units per hectare;
 - b) Traffic considerations;
 - c) Parking spaces;
 - d) Local fire fighting facilities; and
 - e) Water supply, drainage and sanitation requirements.
- 4 The FAR values specified in this table may be increased by 20 percent for the following services:
 - A basement or cellar space under a building constructed on stilts and used as a parking space and airconditioning plant room used as accessory to the principal use;
 - Watchman's booth, pumphouse, garbage shaft, electric cabin or sub-station and other utility structures meant for the services of the building under considerations;
 - Projections and accessory buildings as specifically exempted under the Code; and
 - d) Staircase room and lift rooms above the topmost storey; architectural feature; 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.

5 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.

OPEN SPACES: (3.4.6)

- The open spaces around or inside a building shall conform to the requirements of Part 3 'Development Control Rules and General Building Requirements'.
 - For high rise buildings, the following additional provisions of means of access to the building shall be ensured (see Part 3 'Development Control Rules and General Building Requirements'):
 - The width of the main street on which the building abuts shall not be less than 12 m and one end of this street shall join another street not less than 12 m in width;
 - The road shall not terminate in a dead end; except in the case of residential building, up to a height of 30 m.
 - The compulsory open spaces around the building shall not be used for parking; and
 - Adequate passageway and clearances required for fire fighting vehicles to enter the premises shall be provided at the main entrance; the width of such entrance shall be not less than 4.5 m. If an arch or covered gate is constructed, it shall have a clear head-room of not less than 5 m.

OPENINGS IN SEPARATING WALLS AND FLOORS: : (3.4.8)

- At the time of designing openings in separating walls and floors, particular attention shall be paid to all such factors as will limit fire spread through these openings and maintain fire rating of the structural member.
 - For Types 1 to 3 construction, a doorway or opening in a separating wall on any floor shall be limited to 5.6 m² in area with a maximum height/width of 2.75 m. Every wall opening shall be protected with fire-resisting doors having the fire rating of not less than 2 h in accordance with accepted standard
 - All openings in the floors shall be protected by vertical enclosures extending above and below such openings, the walls of such enclosures having a fire resistance of not less than 2 h and all openings therein being protected with a fire-resisting assembly
 - For Type 4 construction, openings in the separating walls or floors shall be fitted with 2 h fire resisting assemblies.
 - Openings in walls or floors which are necessary to be provided to allow passages of all building services like cables, electrical wirings, telephone cables, plumbing pipes, etc, shall be protected by enclosure in the form of ducts/shafts having afire resistance not less than 2 h.
 - Medium and low voltage wiring running in shafts/ducts, shall either be armored type or run through metal conduits. Further, the space between the conduits pipes and the walls/ slabs shall be filled in by a filler material having fke resistance rating of not less than 1 h.

• VERTICAL OPENING: (3.4.8.4)

- Every vertical opening between the floors of a building shall be suitably enclosed or protected, as necessary, to provide the following:
 - Reasonable safety to the occupants while using the means of egress by preventing spread of fire, smoke, or fumes through vertical openings from floor to floor to allow occupants to complete their use of the means of egress. Further it shall be ensured to provide a clear height of 2100 mm in the passage/escape path of the occupants.

• Limitation of damage to the building and its contents.

• FIRE STOPS: (3.4.9)

Where openings are permitted, they shall not exceed three-fourths the area Of the wall in the case of an external wall and they shall be protected with fire resisting assemblies or enclosures having a fire resistance equal to that of the wall or floor in which these are situated.

AIR-CONDITIONING AND VENTILATION: (3.4.11)

- Air-conditioning and ventilation requirements of different rooms or areas in any occupancy shall be as given in Part 8 'Building Services, Section 1 Lighting and Ventilation and Section 3 Air-conditioning, Heating and Mechanical Ventilation'.
- Air-conditioning and ventilating systems shall be so installed and maintained as to minimize the danger of spread of fire, smoke or fumes from one floor to other or from outside to any occupied building or structure
- Air-conditioning and ventilating systems circulating air to more than one floor or fire area shall be provided with dampers designed to close automatically in case of fire and thereby preventing spread of fume or smoke and shall be in accordance with the accepted standard. Such a system shall also be provided with automatic controls to stop fans in case of fire, unless arranged to remove smoke from a fue, in which case these shall be designed to remain in operation
- Air-conditioning system serving large places of assembly (over 1000 persons), large departmental stores or hotels with over 100 rooms in a single block shall be provided with effective means for preventing circulation of smoke through the system in the case of a fire in air filters or from other sources drawn into the system, and shall have smoke sensitive devices for actuation in accordance with the accepted standards
- From fire safety point of view, separate air handling units for the various floors shall be provided so as to avoid the hazards arising from spread of fire and smoke through the air-conditioning ducts

• **SMOKE VENTING:** (3.4.12)

- Smoke venting facilities for safe use of exits in windowless buildings, underground structures, large area factories, hotels and assembly buildings (including cinema halls) shall be automatic in action with manual controls in addition.
- Natural draft smoke venting shall utilize roof vents or vents in walls at or near the ceiling level; such vents shall be normally open, or, if closed, shall be designed for automatic opening in case of fire, by release of smoke sensitive devices.
- Where smoke venting facilities are installed for purposes of exit safety, these shall be adequate to prevent dangerous accumulation of smoke during the period of time necessary to evacuate the area served, using available exit facilities with a margin of safety to allow for unforeseen contingencies. It is recommended that smoke exhaust equipment should have a minimum capacity of 12 air changes per hour

• WATER SUPPLY FOR FIRE FIGHTING PURPOSES: (4.1.4)

- The Authority shall make provision to meet the water supply requirements for fire fighting in the city/area, depending on the population density and types of occupancy.
- Provision shall be made by the owner of the building for water supply requirements for fire fighting purposes within the building
- Fire hydrants must be provided at suitable locations in buildings over 24 m in height.
- In buildings of height upto 60 m, special pressure reducing and special pump arrangements should be made to meet requirements of water. Each hydrant must be fed by pump of capacity of 275 litres/minute. This pump should draw water from storage tank having minimum storage 2×105 litres.

• SURFACE FINISHES: (3.4.15)

- The use of combustible surface finishes on walls (including facade of the building) and ceilings affects the safety of the occupants of a building. Such finishes tend to spread the fire and even though the structural elements may be, ,adequately fire resistant, serious danger to life may result. It is, therefore, essential to have adequate precautions to minimize spread of flame on wall, facade of building and ceiling surfaces.
- The finishing materials used for various surfaces and decor shall be such that it shall not generate toxic smoke/fumes.
- The susceptibility to fire of various types of wall surfaces is determined in terms of the rate of spread of flame. Based on the rate of spread of flame, surfacing material shall be considered as divided into four classes as follows:
 - Class 1 Surfaces of very low flame spread.
 - Class 2 Surfaces of low flame spread.
 - Class 3 Surfaces of medium flame spread.
 - Class 4 Surfaces of rapid flame spread.
- The uses for which surface materials falling into various classes shall be adopted in building construction are given below:

Class 1 Class 2 Class 3

May be May be used in used in any any situation, situation except on walls, facade of the building, staircase and corridors

May be used only in living rooms and bed rooms (but not in rooms on the roof) and only as a lining to solid walls and partitions; not on staircases or corridors or facade of the building.

Materials of Class 4 which include untreated wood fibreboards may be used with due fire retardant

treatment as ceiling lining, provided the ceiling is at

least, 2.4 m from the top surface of the floor below,

and the wall surfaces conform to requirements of class.

Class 4 materials shall not be used in kitchens, corridors and staircases. Some materials contain bitumen and, in addition to risk from spread of fire, emit dense smoke on burning; such materials shall be excluded from use under these conditions and shall also not be used for construction of ceiling where the plenum is used for return air in air-conditioned buildings

• GLAZING: (3.4.16)

- Building of Types 1 to 4 construction shall employ one of the two types of glazing described in except that Type 4 construction may have the alternative of hardwood sashes or frames or both.
- Wired glass shall comply with the following requirements:
 - Wired glass The wired glass shall be of minimum half hour fire resistance rating.
 - Sashes and frames The sashes or frames or both shall be entirely of iron or other suitable metal such as stainless steel, securely bolted or keyed into the wall, except in the case of panels in internal doors.
 - Setting of glass The panels of glass shall be set in rebates or grooves not less than 6.0 mm in width or depth, with due allowance for expansion, and shall be secured by hard metal fastenings to the sashes or frames independently of any cement or putty used for weather-proofing purposes. AREA OF ONE GLASS SHOULD NOT BE MORE THAN 2500 CM²

- Electro-copper glazing shall comply with the following requirements:
 - Electro-copper glazing The electro-copper glazing shall be of minimum half hour fire resistance rating.
 - Sashes and frames The sashes or frames or both shall be entirely of iron or other hard metal, securely bolted or keyed into the wall, except when in panels in internal doors.
 - Fixing of sectional lights The sectional lights shall be set in rebate or grooves not less than 6.5 mm in width or depth, with due allowance for expansion and shall be secured by hard metal fastenings to the sashes or frames independently of any lead, cement or putty used for weather-proofing purposes.

EXIT REQUIREMENTS IN BUILDINGS FOR FIRE RESISTANCE

- An exit may be a doorway; corridor; passageway(s) to an internal staircase, or external staircase, or to a *VERANDAH or terrace(s)*, which have access to the street, or to the roof of a building or a refuge area. An exit may also include a horizontal exit leading to an adjoining building at the same level.
- Lifts and escalators shall not be considered as exits.
- Every exit, exit access or exit discharge shall be continuously maintained free of all obstructions or impediments to full use in the case of fire or other emergency.
- Every building meant for human occupancy shall be provided with exit sufficient to permit safe escape of occupants, in case of fire or other emergency.
- All exits must be clearly visible and routes leading to exits should be marked and signs posted to guide the occupants.
- Adequate lighting, illumination and ventilation should be provided at exits.
- Fire fighting equipments must be located suitably and marked,
- Fire alarm devices should be installed
- All exists should provide continuous means of access to the exterior of building or an exterior open space leading to street
- Exits shall be so arranged that they may be reached without passing through another occupied unit.

• OCCUPANT LOAD:

• For determining the exits required, the number of persons within any floor area or the occupant load shall be based on the actual number of occupants.

Table 20 Occupant Load

(Clause 4.3)

SI No.	Group of Occupancy	Occupant Load, Floor Area in m²/Person
(1)	(2)	(3)
i)	Residential (A)	12.5
ii)	Educational (B)	4
iii)	Institutional (C)	15 (see Note 1)
iv)	Assembly (D)	
	 a) With fixed or loose seats and dance floors 	0.6 (see Note 2)
	 Without seating facilities including dining rooms 	1.5 (see Note 2)
v)	Mercantile (F)	
	 a) Street floor and sales basement 	3
	 b) Upper sale floors 	6
vi)	Business and industrial (E&G)	10
vii)	Storage (H)	30
viii)	Hazardous (J)	10

NOTES

- 1 Occupant load in dormitory portions of homes for the aged, orphanages, insane asylums, etc, where sleeping accommodation is provided, shall be calculated at not less than 7.5 m² gross floor area/person.
- 2 The gross floor area shall include, in addition to the main assembly room or space, any occupied connecting room or space in the same storey or in the storeys above or below, where entrance is common to such rooms and spaces and they are available for use by the occupants of the assembly place. No deductions shall be made in the gross area for corridors, closets or other sub-divisions; the area shall include all space serving the particular assembly occupancy.

Table 21 Occupants per Unit Exit Width

(Clauses 4.4.2, 4.4.3 and C-1.6.2)

SI No.	Group of	Number of Occupants				
140.	Occupancy	Stairways	Ramps	Doors		
(1)	(2)	(3)	(4)	(5)		
i)	Residential (A)	25	50	75		
ii)	Educational (B)	25	50	75		
iii)	Institutional (C)	25	50	75		
iv)	Assembly (D)	40	50	60		
v)	Business (E)	50	60	75		
vi)	Mercantile (F)	50	60	75		
vii)	Industrial (G)	50	60	75		
viii)	Storage (H)	50	60	75		
ix)	Hazardous (J)	25	30	40		

CAPACITIES OF EXIT:

The unit of exit width, used to measure the capacity of any exit, shall be 500 mm. A clear width of 250 mm shall be counted as an additional half unit. Clear widths less than 250 mm shall not be counted for exit width.

- NOTE— The total occupants from a particular floor must evacuate within 2.5 minutes for Type 1 construction, 1.5 minutes for Type 2 construction and 1 minute for Type 3 construction.
- When horizontal exit is provided in buildings of mercantile, storage, industrial, business and assembly occupancies, the capacity per storey per unit width of exit of stairways in Table 21 may be increased by 50 percent and in buildings of institutional occupancy it may be increased by 100 percent.

ARRANGEMENT OF EXITS:

Exits shall be so located that the travel, distance on the floor shall not exceed the distance given in Table 22. The travel distance to an exit from the dead end of a corridor shall not exceed half the distance specified. in Table 22, except in assembly and institutional occupancies in which case it shall not exceed 6 m. Whenever more than one exit is required for any room space or floor of a building, exits shall be placed as remote from each other as possible and shall be arranged to provide direct access in separate directions from any point in the area served.

Table 22 Travel Distance for Occupancy and Type of Construction

(Clauses 4.4.1, 4.5.1 and 4.5.2)

SI No.	Group of Occupancy	Maximum Travel Distance Construction				
		Types 1 & 2 m	Types 3 & 4 m			
(1)	(2)	(3)	(4)			
i)	Residential (A)	30.0	22.5			
ii)	Educational (B)	30.0	22.5			
iii)	Institutional (C)	30.0	22.5			
iv)	Assembly (D)	30.0	30.0			
v)	Business (E)	30.0	30.0			
vi)	Mercantile (F)	30.0	30.0			
vii)	Industrial (G)	45.0	1)			
viii)	Storage (H)	30.0	D)			
ix)	Hazardous (J)	22.5	1)			

NOTES

- 1 For fully sprinklered building, the travel distance may be increased by 50 percent of the values specified.
- 2 Ramps shall be protected with automatic sprinkler system and shall be counted as one of the means of escape.
- Onstruction of type 3 or 4 is not permitted.

• NUMBER OF EXITS:

- All buildings, which are 15 m in height or above, and all buildings used as educational, assembly, institutional, industrial, storage, and hazardous occupancies and mixed occupancies with any of the aforesaid occupancies, having area more than 500 m2 on each floor shall have a minimum of two staircases.
- They shall be of enclosed type; at least one of them shall be on external walls of buildings and shall open directly to the exterior, interior open space or to an open place of safety.

• EXIT DOORWAY:

- Every exit doorway shall open into an enclosed stairway or a horizontal exit of a corridor or passageway providing continuous and protected means of egress.
- No exit doorway shall be less than 1000 mm in width except assembly buildings where door width shall be not less than 2000 mm. Doorways shall be not less than 2000 mm in height.
- Exit doorways shall open outwards, that is, away from the room, but shall not obstruct the travel along any exit. No door, when opened, shall reduce the required width of stairway or landing to less than 900 mm; overhead or sliding doors shall not be installed.
- NOTE In the case of buildings where there is a central corridor, the doors of rooms shall open inwards to permit smooth flow of traffic in the corridor.
- Exit door shall not open immediately upon a flight of stairs; a landing equal to at least the width of the door shall be provided in the stairway at each doorway; the level of landing shall be the same as that of the floor which it serves.
- Exit doorways shall be openable from the side which they serve without the use of a key.
- Mirrors shall not be placed in exit ways or exit doors to avoid confusion regarding the direction of exit.

• CORRIDORS AND PASSAGEWAYS:

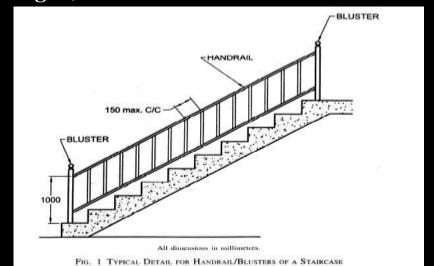
- Exit corridors and passageways shall be of width not less than the aggregate required width of exit doorways leading from them in the direction of travel to the exterior.
- Where stairways discharge through corridors and passageways, the height of corridors and passageways shall be not less than 2.4 m.
- All means of exit including staircases lifts lobbies and corridors shall be adequately ventilated.

INTERNAL STAIRCASES:

- Internal stairs shall be constructed of noncombustible materials throughout.
- Internal stairs shall be constructed as a selfcontained unit with an external wall of the building constituting at least one of its sides and shall be completely enclosed.
- A staircase shall not be arranged round a lift shaft.
- Hollow combustible construction shall not be permitted.
- No gas piping or electrical panels shall be allowed in the stairway. Ducting in stairway may be permitted if it is of 1 h fire resistance rating.
- Minimum width of staircases:

a)	Residential buildings (dwellings)	1.0 m
b)	Residential hotel buildings	1.5 m
c)	Assembly buildings like auditorium, theatres and cinemas	2.0 m
d)	Educational buildings up to 30 m in height	1.5 m
e)	Institutional buildings like hospitals	2.0 m
f)	All other buildings	1.5 m

- The minimum width of tread without nosing shall be 250 mm for internal staircase of residential buildings. This shall be 300 mm for assembly, hotels, educational, institutional, business and other buildings.
- The treads shall be constructed and maintained in a manner to prevent slipping.
- The maximum height of riser shall be 190 mm for residential buildings and 150 mm for other buildings and the number shall be limited to 15 per flight.
- Handrails shall be provided at a height of 1000 mm to be measured from the base of the middle of the treads to the top of the handrails. Balusters/railing shall be provided such that the width of staircase does not reduce (see Fig. 1).



• INTERNAL STAIRCASES:

- The design of staircase shall also take into account the following:
- The minimum headroom in a passage under the landing of a staircase and under the staircase shall be 2.2 m.
- For building 15 m in height or more, access to main staircase shall be through a fire/smoke check door of a minimum 2 h fire resistance rating. Fire resistance rating may be reduced to 1 h for residential buildings (except hotels and starred hotels).
- No living space, store or other fire risk shall open directly into the staircase or staircases.
- External exit door of staircase enclosure at ground level shall open directly to the open spaces or through~ a large lobby, if necessary.
- The main and external staircases shall be continuous from ground floor to the terrace level.
- No electrical shafts/AC ducts or gas pipes, etc, shall pass through or open in the staircases.
- Lifts shall not open in staircase.
- No combustible material shall be used for decoration/wall paneling in the staircase.
- Beams/columns and other building features shall not reduce the head room/width of the staircase.

INTERNAL STAIRCASES:

- The exit sign with arrow indicating the way to the escape route shall be provided at a suitable height from the floor level on the wall and shall be illuminated by electric light connected to corridor circuits. All exit way marking signs should be flush with the wall and so designed that no mechanical damage shall occur to them due to moving of furniture or other heavy equipments. Further, all landings of floor shall have floor indicating boards prominently indicating the number of floor as per byelaws.
- The floor indication board shall be placed on the wall immediately facing the flight of stairs and nearest to the landing. It shall be of size not less than $0.5 \text{ m} \times 0.5 \text{ m}$.
- Individual floors shall be prominently indicated on the wall facing the staircases.
- In case of single staircase it shall terminate at the ground floor level and the access to the basement shall be by a separate staircase. The second staircase may lead to basement levels provided the same is separate at ground level by ventilated lobby with discharge points to two different ends through enclosures.

• EXTERNAL STAIRCASES:

- External stairs, when provided shall comply the following:
 - External stairs shall always be kept in sound operable conditions.
 - Ail external stairs shall be directly connected to the ground.
 - Entrance to the external stairs shall be separate and remote from the internal staircase.
 - Care shall be taken to ensure that no wall opening or window opens onto or close to an external stairs.
 - The route to the external stairs shall be free of obstructions at all times.
 - The external stairs shall be constructed of noncombustible materials, and any doorway leading to it shall have the required fire resistance.
 - No external staircase, used as a fire escape, shall be inclined at an angle greater than 45° from the horizontal.
 - External stairs shall have straight flight not less than 1250 mm wide with 250 mm treads and risers not more than 190 mm. The number of risers shall be limited to 15 per flight.
 - Handrails shall be of a height not less than 1000 mm and not exceeding 1200 mm. There shall be provisions of balusters with maximum gap of 150 mm.
 - The use of spiral staircase shall be limited to low occupant load and to a building

- RAMPS:
- The slope of a ramp shall not exceed 1 in 10.
- In certain cases steeper slopes maybe permitted but in no case greater than 1 in 8.
- For all slopes exceeding 1 in 10 and wherever the use is such as to involve danger of slipping, the ramp shall be surfaced with approved non-slipping material.

HORIZONTAL EXITS

- The width of horizontal exit shall be same as for the exit doorways.
- A horizontal exit shall be equipped with at least one fire/smoke door of minimum 1 h fire resistance of self-closing type. Further, it is required to have direct connectivity to the fire escape staircase for evacuation.
- For buildings more than 24 m in height, refuge area of 15 m² or an area equivalent to 0.3 m² per person to accommodate the occupants of two consecutive floors, whichever is higher, shall be provided as under:
- Where there is a difference in level between connected areas for horizontal exits, ramps, not more than 1 in 10 m slope shall be provided; steps shall not be used.
- Doors in horizontal exits shall be openable at all times from both sides.

FIRE LIFTS

- Where applicable, fire lifts shall be provided with a minimum capacity for 8 passengers and fully automated with emergency switch on ground level. In general, buildings 15 m in height or above shall be provided with fire lifts.
- In case of fire, only fireman shall operate the fire lift. In normal course, it may be used by other persons.
- Each fire lift shall be equipped with suitable inter-communication equipment for communicating with the control room on the' ground floor of the building.
- The number and location of fire lifts in a building shall be decided after taking into consideration various factors like building population, floor area, etc.

FIRE TOWER

- Fire towers are the preferred type of escape route for storied buildings and these shall be considered as the safest route for escape. Their number, location and size shall depend on the building concerned, and its associated escape routes.
- In high rise buildings with over 8 storeys or 24 m in height, at least one required means of egress shall preferably be a fire tower.
- The fire towers shall be constructed of walls with a 2 h fire resistance rating withou openings other than the exit doorways, with platforms, landings and balconies having the same fire-resistance rating.

METHODS OF THERMAL INSULATION

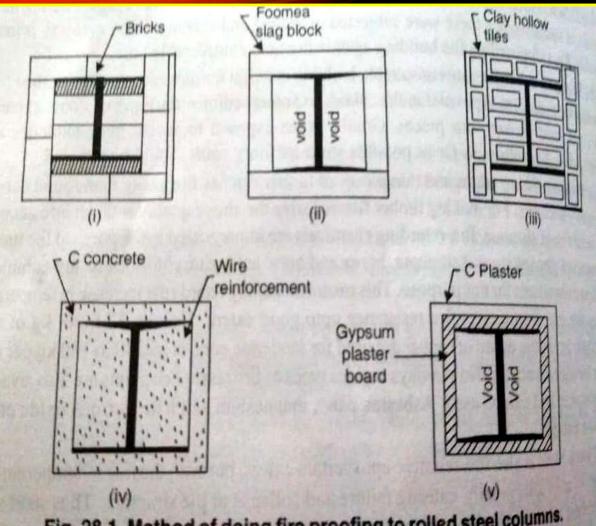


Fig. 28.1. Method of doing fire proofing to rolled steel columns.

