

REVIEW ON FIRE REGULATIONS FOR NEW HIGH-RISE COMMERCIAL BUILDINGS IN HONG KONG AND A BRIEF COMPARISON WITH THOSE IN OVERSEAS

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(Received 7 March 2001; Accepted 10 April 2001)

ABSTRACT

Fire safety regulations for new high-rise commercial buildings in Hong Kong were briefly reviewed. Key areas on the proposed improvement appeared in the government consultation paper were identified. A comparison with the fire regulations for high-rise buildings in China Mainland, U.K and U.S.A. was made.

1. INTRODUCTION

There are many high-rise buildings in Hong Kong (now the Hong Kong Special Administrative Region HKSAR). Special attention should be paid on fire safety, especially for those with multiple occupancies. It is likely that a small fire accident in a high-rise building with multiple tenants might be turned into disasters with severe human deaths and injuries as well as property loss [1]. Note that different fire safety standards are adopted in separate occupancies and it is more difficult to be managed by multiple ownership. High-rise buildings are defined in local regulations as [2]:

A building of which the floor of the uppermost storey exceeds 30 m above the point of staircase discharge at ground floor level.

In the past few years, several big fires occurred in those old high-rise buildings [3-6], with the biggest one having 39 people killed. Local citizens are now starting to be aware of the fire safety issues. The government has decided to improve the fire safety aspects by setting up tighter regulations for new high-rise commercial buildings. A consultation paper extending Fire Safety (Commercial Premises) Ordinance was then issued in 1997 [7]. This is a big step advanced by the local government where longer term plannings are likely to be made for the region. Before understanding whether the new regulations are appropriate, a critical review on those current fire regulations for new high-rise buildings should be made.

Upon smooth reunification of Hong Kong to China in July, 1997, reviewing the fire regulations related to high-rise buildings in the Mainland [8-11] and comparing them with those in Hong Kong is good for strengthening the interflow of technology between the two administrative systems of the

country. In addition, international codes and standards were reviewed. Those are The Building Regulations 1991 Approved Document B: Fire Safety [12]; Fire Precautions Act [13]; Greater London Council (GLC) London Building Act [14,15]; The Chartered Institution of Building Services Engineers (CIBSE) Guide E: Fire engineering [16] which is for fire safety in UK; and National Fire Protection Association (NFPA) 101 Life Safety Code [17], which is an American fire safety standard; and the four model building codes in USA [18-24], including Building Officials and Code Administrators International (BOCA) National Building Code (NBC) 1996 [18]; International Conference of Building Officials (ICBO) Uniform Building Code (UBC) 1997 [20]; Southern Building Code Congress International (SBCCI) Standard Building Codes (SBC) 1997 [23]; and International Code Council (ICC) International Building Code (IBC) 2000 [24]. The first three govern various states in USA, the last one is consolidated from the first three building codes and is used to replace them.

Reporting the results of the investigations is the objective of this paper. The definitions for different terms are reviewed and listed in Appendix A.

2. LOCAL FIRE SAFETY REQUIREMENTS

Fire safety requirements are different for residential and non-residential buildings. People staying in residential buildings are supposed to be familiar with the building environment and the location of the escape routes. High fire load density is not expected, though there is reservation on this statement because some records on residential building fires indicated that the fire load density was likely to be higher than the specified upper

limit of $1,135 \text{ MJm}^{-2}$ [2] based on the fire duration observed. But it is difficult to set up regulations for old residential buildings because of the social pressure. There were serious criticisms even on carrying out routine checking of alarms and conducting fire drills. Therefore, only non-residential buildings are considered at this stage.

At least two key factors on fire safety must be considered: the amount of combustibles described by the fire load density; and the number of people staying inside the building expressed in terms of the occupancy levels. As a result of the probable high fire load density and high population density, a list of fire safety provisions covered by two key areas is required in new high-rise commercial buildings [2,25]:

- **Building Structures:**

Include all passive building design, such as fire resisting construction, means of escape and means of access, which are aimed at providing sufficient means of egress from the building and sufficient means of access for fire fighting and rescue, maintaining the integrity of the building structure and preventing spread of fire when a fire occurs. Those are basically taken care of by the government Buildings Department (BD).

- **Fire Safety Measures:**

Include all fire service installations or equipment, such as fire alarm system, detection system, sprinkler system, emergency lighting, fire hydrant/hose reel system and so on, which are used for extinguishing, attacking, preventing or limiting a fire; giving warnings of a fire; providing access to any premises for extinguishing, attacking, preventing or limiting a fire. The government Fire Services Department (FSD) would watch this part.

The requirements are clearly described in the Fire Safety (Commercial Premises) (Amendment) Ordinance [26] for new commercial buildings (premises with floor area over 230 m^2).

For old high-rise buildings, only fire hydrant and hose reel systems were required before 1973. Sprinkler systems and fire detection systems are not commonly found. There might be problems in locating the means of escape and means of access. Further, it is difficult to identify the fire resisting construction elements because of some reallocation works carried out without reporting to the BD in the past 28 years. A consultation paper [7] on

upgrading the fire safety in old high-rise buildings was distributed to the public for comments under the democratic policy of the new government. In 1998, the existing Fire Safety (Commercial Premises) Ordinance was extended to include all commercial buildings and those old high-rise buildings constructed before 1973 and amended as Fire Safety (Commercial Premises) (Amendment) Ordinance [26]. The new enactment was generated after a severe fire disaster happened in a high-rise commercial building in 1996. Further, a Building Safety Inspection Scheme (BSIS) was implemented by the BD to ensure safety in buildings. Essentially, the integrity of external finishes, structural stability, and fire safety are assessed [27].

Basically, the two key areas on 'Building Structure' and 'Fire Safety Measures' in the Fire Safety (Commercial Premises) Ordinance are referred to. On the other hand, fire safety management is considered to be important as addressed by the Chief Secretary of the government in 1998 [28].

3. LOCAL REQUIREMENTS ON BUILDING STRUCTURES

Fire resistance period (FRP) is a key factor in local fire codes [29]. The required FRP for elements of construction is generally designated as 1 hour, 2 hours and 4 hours. Elements of means of egress and means of access are specified with adequate FRP. All liftwell enclosure should be separated from other parts of the building by a minimum of 2-hour FRP. Any door to a liftwell wall should have an FRP of not less than 1 hour in terms of integrity and insulation.

All required staircases and lobbies connected to them should have an FRP of not less than that for the construction elements of the compartments next to them. "Non-combustible" materials should be used for staircases enclosure. Internal corridor and balcony approach corridor serving rooms in separate occupancies should be protected by an FRP of not less than 1 hour. The doors on them should have an FRP longer than half an hour. The requirements on the FRP of construction elements in the local codes as well as other codes are listed in Table 1. Comparisons with other codes will be made later in this paper.

Buildings with a big space volume should be divided into different compartments by structural elements in order to limit the spread of fire and reduce the number of persons exposed to the fire. The maximum compartment size is specified

according to their cubical extent. The maximum compartment volume allowed is 28,000 m³ for spaces above ground, but it is reduced to 7,000 m³ for underground spaces. The above fire compartment size is allowable to increase if an equivalent fire safety standard is achieved. The requirements on compartment size for local premises and overseas buildings are listed in Table 2.

All the elements of construction, compartment walls and floors should have an FRP as listed in the Code. For domestic buildings, hotel bedrooms and offices, a minimum FRP of 1 hour should be provided. On the other hand, at least 2 hours should be provided for industrial buildings and warehouses. For compartments in basements, the FRP should not be less than 4 hours.

The number of staircases required in local high-rise commercial buildings is determined by the occupant load of each story, which can be assessed by prescribed factors for different occupancies stated in the Code [30]. The various intended uses of a building or a story are categorized by a factor, namely the usable floor area per person A_{per} . It varies from 0.5 m² per person for assembly halls to 30 m² per person for warehouses. Normally, it is not acceptable for buildings having more than six stories or more than 17 m high to have just one single staircase; at least two staircases must be provided. For non-domestic single-use buildings, occupants should be able to gain access to the other staircase without passing through some private areas, when they are using one of them. Staircases are not permitted to continue down to any basement levels. At least two exits are required in each basement. In Table 3, the requirements on escape routes, including the minimum number of exit doors and exit routes, are listed according to the capacity of the room or storey. In addition, a comparison on the minimum width and number of staircases among all codes is shown in Table 4. Discussions on these will be carried out later in this paper.

The minimum width of exit routes, determined by the occupant load, is also shown in Table 3. Where at least two exit routes should be provided in a premise, the width for the exit route or stairway should be at least 1050 mm. More specifically, stairways serving not more than 300 persons from a story should be at least 1.2 m wide, while for those serving more than 300 persons, their width should be at least 1.5 m. The clear height of all staircases is 2 m.

Table 1: Requirements on fire resistance period (FRP)

Constructions	Hong Kong* [29]	Mainland [9,10]		Approved Document B*	Fire Precautions Act* [13]	GLC London Building Act% [14,15]	NFPA 101#% [17]	Model building codes [18-24]	CIBSE Guide E [16]
		First class	Second class						
Fire resisting wall	1,2,4	4	4				0.5,1,2		Equivalent FRP for enclosed spaces is calculated by an equation.
Load bearing wall	1,2,4	3	2.5	1,1.5,2			2,3,4		
Floor slab	1,2,4	1.5	1	1,1.5,2	0.5	0.5,1,2,4	2,3		
Columns	1,2,4	3	2.5	1,1.5,2		0.5,1,2,4	2,3,4		
Beams	1,2,4	2	1.5	1,1.5,2		0.5,1,2,4	2,3,4		
Roof	1,2,4	1.5	1	1,1.5,2		0.5,1,2,4	1.5,2		
Lift well	2	3	2.5	0.5	0.5	0.5,1,2,4			
Stair enclosure	1,2,4	3	2.5	0.5	0.5	0.5,1,2,4			
Compartment wall	1,2,4	0.75	0.5	1,1.5,2	0.5,1	0.5,1,2,4			
Non-load bearing external walls of escape route	1,2,4	1	1	0.5	0.5	0.5,1,2,4			
Hanging roof		0.25	0.25**						

* FRP depends on the intended functions of the building.

** Materials which are difficult to ignite or treated with fire retardants. % # Subjected to different materials. Elements are of Type 1 approved noncombustible or limited-combustible materials.

Table 2: Requirements on compartment size

	Classifications	Maximum compartment size	Remarks	
Local code [29]	Above ground	28000 m ³	• Defined by volume.	
	Underground	7000 m ³		
Mainland code [9,10]	Type1	1000 m ²	• Defined by floor area.	
	Type 2	1500 m ²		
	Underground	500 m ²		
Approved Document B [12]	Offices	No limit	• Defined by floor area.	
	Residential (institutional)	2000 m ²		
	Assembly & recreation, shop & commercial	2000 m ² 4000 m ² (s)		
	Industrial	Not more than 20 m		7000 m ² 14000 m ² (s)
		More than 20 m		2000 m ² 4000 m ² (s)
	Storage & other non-residential	Not more than 20 m		20000 m ² 40000 m ² (s)
More than 20 m		4000 m ² 8000 m ² (s)		
NFPA 101 [17]	Assembly, day-care, detention and correctional, hotels and dormitories, apartment, residential board and care, industrial, storage	Not mentioned.	• Defined by floor area.	
	Educational	2800 m ²		
	Health care, ambulatory health care	2100 m ²		
	Mercantile, business	No requirement.		
Fire Precautions Act & GLC London Building Act [13-15]	No requirements.			
Model building codes [18-24]	No information.			
CIBSE Guide E [16]	Not mentioned.		• Defined by floor area.	

(s) Represents sprinklered building

Table 3: Requirements on escape routes in local codes

Capacity of room or storey	Minimum number of exit doors (from room) or exit routes (from storey)	Minimum total width/mm		Minimum width/mm	
		exit doors	exit routes	exit doors	exit routes
4 - 30	1			750	1050
31 - 200	2	1750	2100	850	1050
201 - 300	2	2500	2500	1050	1050
301 - 500	2	3000	3000	1050	1050
501 - 750	3	4500	4500	1200	1200
751 - 1000	4	6000	6000	1200	1200
1001 - 1250	5	7500	7500	1350	1350
1251 - 1500	6	9000	9000	1350	1350
over 1500	7 or higher as required by the Authority	to be calculated at the rate of 300 mm per 50 persons		1500	1500

Table 4: Requirements on escape stairways

	Minimum requirements	
	Number of staircases	Width of staircases (m)
Local code [30]	2	1.1
Mainland code [9,10]	2	1.1
Approved Document B [12]	2	0.8
Fire Precautions Act [13]	2	0.75
GLC London Building Act [14,15]	2	1.1
NBC 96 [18,19]	2	1.1
UBC 97 [20-22]	-	0.91
SBC 97 [23]	2	1.1
IBC 2000 [24]	2	1.1
NFPA 101 [17]	2	0.91

The measurement of distance in an escape route is separated into 2 portions:

- Direct distance: measured from any part in a room to the centre of the exit door of the room;
- Travel distance: measured from the exit door of the room to the centre of the fire door of an exit stairway.

The limitations on them are classified by the different uses of the premises with three exit route approaches including the balcony approach (with ventilation), internal corridor (without ventilation) and a type other than those mentioned above. The first approach deserves the largest travel distance and direct distance. For offices, shops and schools, the maximum sum of the two distance measurements is 45 m, 36 m and 30 m for the three approaches respectively. In all other cases, they should be 36 m, 36 m and 30 m instead. The travel distance limitation is shown in Table 5, with comparison made to the other codes.

Other than the means of escape, there are requirements for the means of access. For high-rise buildings, at least two access staircases for the access of firefighters should be provided [31]. The number of access staircases required is identical to that of the escape staircases. Staircases, in this respect, can serve for these two purposes. At least one fireman's lift is prescribed to construct within 60 m from any floor for buildings with two or more lifts.

4. LOCAL REQUIREMENTS ON FIRE SAFETY MEASURES [2]

Fire hydrant/hose reel systems must be provided in high-rise buildings and located within 30 m from any part of the building. The actuating point of the fire alarm system should be located at each hose reel point with the installation of an audio warning device.

Sprinkler systems are required in most of the non-residential buildings and they should be installed at every part of the building, including staircases and corridors. An automatic cut-off system should be provided to stop the mechanically induced air movement of a ventilation system in the building.

An independent emergency generator should be provided. In the whole building and at all escape routes, emergency lighting and exit signs should be available. Artificial lighting is required to reach 30 lux at floor level of the exit routes. In case of the normal lighting fails, emergency lighting should provide a minimum of 2 lux at floor level.

5. HIGH-RISE BUILDINGS IN THE MAINLAND

The definition of high-rise building is clearly stated in the Codes [9,10] of China. High-rise buildings in Mainland China include those residential buildings having more than 10 stories and those public buildings with a floor level higher than 24 m above ground level. More specifically, they are further categorized into two types with respect to their usage, fire hazard class, means of escape and level of difficulty in firefighting and rescue [9,10].

- Type 1 high-rise buildings:
 - High class residential buildings.
 - Residential buildings having at least 19 stories.
 - Hospitals, high class hotels.
 - Public or commercial buildings exceeding 50 m.
 - Commercial buildings with each floor area exceeding 1,000 m².
 - Commercial-residential composite buildings with each floor area exceeding 1,500 m².
 - Major utilities buildings.
 - Big libraries (more than one million books).
 - Important buildings.

- Type 2 high-rise buildings:
 - Residential buildings having 10-18 stories.
 - Commercial buildings, commercial-residential composite buildings other than Type 1 high-rise buildings.
 - Small utilities buildings.
 - Hotels, offices, institutional buildings not exceeding 50 m.
- Requirements on Building structures in the Mainland

Fire resistance period is divided into two grades. Grade 1 fire resistance is for Type 1 high-rise buildings while Grade 2 fire resistance is for Type 2 high-rise buildings. Basement levels should also be constructed of Grade 1 fire resistance. Fire resistance ratings are given to the elements of construction. For fire-resisting walls, non-loadbearing walls, walls enclosing escape routes and hanging roofs, the two grades require the same FRP. Other than those mentioned above, Grade 1 is more stringent than Grade 2, that means a longer fire resistance period is required. All these construction elements should be made of noncombustible materials, except Grade 2 hanging roof.

Underground staircases should be protected by an FRP of not less than 3 hours and can directly lead to outdoor area. Other stairway enclosures and lift well should have an FRP of at least 3 hours and 2.5 hours respectively for Grade 1 and Grade 2 requirements. The FRP for escape routes is 1 hour for both grades. More details on the fire resistance period for the elements of construction are listed in Table 4.

Fire compartments are determined by the floor area. The maximum compartment size is 1000 m² for Type 1 buildings; 1500 m² for Type 2 buildings and 500 m² for basements. For premises installed with an automatic sprinkler system, the above compartment size can be doubled.

Compartments in shopping areas and exhibition areas can be enlarged to 4000 m² for above ground spaces and 2000 m² for underground spaces if an automatic sprinkler system and an automatic fire alarm system are installed.

High-rise buildings are required to have at least two escape exits or staircases. For all Type 1 buildings, Type 2 buildings exceeding 32 m above ground, tower type and unit type domestic buildings with more than 18 stories, and balcony-corridor type residential buildings exceeding 11

stories, smoke lobbies of at least 6 m² in area, fire doors, smokeproof enclosures and smoke extraction system are required.

The minimum width of exit doors and corridors are specified according to different uses of the buildings. A minimum of 1.3 m, 1.1 m and 1.2 m are required for exit doors in hospitals, residential buildings and other buildings respectively. Corridors should have 1.4 m, 1.2 m and 1.3 m in width correspondingly. The minimum widths of escape stairs are also specified for the three categories mentioned above. They are respectively 1.3 m, 1.1 m and 1.2 m. Escape routes for 100 persons should be at least 1 m wide.

Openings, other than fire doors and windows, are not accepted to construct in the staircase. Fire doors should have an FRP longer than 0.9 hour.

The maximum travel distance is specified for different uses of the premises usage, which are classified into three categories, as shown in Table 5. For general buildings, the maximum travel distance is limited to 40 m, and that for educational buildings, hotels and exhibition halls is 30 m and that for hospital wards is 24 m. The maximum travel distance in dead-end corridors should be half of those mentioned above.

For Type 1 buildings, tower type residential buildings, unit type or balcony-corridor type residential buildings with more than 11 stories, and Type 2 buildings higher than 32 m, all are required to have fireman's lifts. The required number of fireman's lift is based on the floor area of the largest story. Only one is required if the largest floor area is less than 1500 m²; and three are expected for a floor area larger than 4500 m². Fireman's lifts can be shared with occupant lifts. It is recommended to locate the fireman's lifts in separate fire compartments. They should be constructed with smoke lobbies and their enclosure of FRP longer than 2.5 hours.

- Requirements on Fire Safety Measures

Fire hydrants should be installed at each floor of all high-rise buildings. Automatic sprinkler systems are required for Type 1 buildings, including rooms for public activities, offices and corridors.

Automatic cut-off devices should be provided for any mechanical ventilation system required for protected staircases, protected lobbies and rooms without natural ventilation.

Table 5: Requirements on travel distance

	Use of premise	Maximum travel distance(m)	Remarks	
Local code [30]	Office, school and shop	36	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes. The distance from any point within a room to the corridor door is defined as "direct distance". It is the maximum sum of the direct distance and travel distance. Apply to internal corridor only. 	
	Others	36		
Mainland code [9,10]	Hospital	wards	24	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes. Measured from room door to story exit.
		others	30	
	Educational building, hotel and exhibition hall		30	
	Others		40	
Approved Document B [12]	Institutional, bedrooms, building for handicapped		18	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes.
	Bedroom corridor		35	
	Assembly and recreation		32	
	Office, shop and commercial, storage, industrial		45	
Fire Precautions Act [13]	Factory		45	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes. Normal fire risk.
	Shop		30	
	Office		45	
GLC London Building Act [14,15]	Offices, factories, warehouses		45 ^a	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes.
	Departmental stores, shops, restaurants, cafes		45 ^a	
	Hotels, boarding houses, hostels		30 ^b	
NBC 96 [18,19]	Assembly, business, educational, factory F-1, institutional I-1, mercantile, residential, storage S-1, utility		61	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes. Nonsprinklered buildings.
	Factory F-2, storage S-2		91	
	Institutional I-2, I-3		45	
UBC 97 [20-22]	Educational		45	<ul style="list-style-type: none"> Nonsprinklered buildings.
	Others		61	
SBC 97 [23]	Assembly, business, educational, factory industrial, mercantile, residential		61	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes. Nonsprinklered buildings.
	Institutional		46/varies	
IBC 2000 [24]	Assembly, educational, factory and industrial F-1, institutional I-1, mercantile, residential, storage S-1, business		61	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes. Nonsprinklered buildings.
	Factory and industrial F-2, storage S-2, utility		91	
	Institutional I-2, I-3, I-4		46	
NFPA 101 [17]	Assembly, educational, day-care, ambulatory health care, detention and correctional		45	<ul style="list-style-type: none"> All are for new buildings and; Non-sprinklered buildings.
	Hotels and dormitories, apartments, board and care		53	
	Business, industrial, storage		60	
	Mercantile		30	
CIBSE Guide E [16]			45	<ul style="list-style-type: none"> The above travel distance is for cases with more than 1 escape routes.

^a Result obtained by multiplying the direct distance by 1.5

^b Measured from any point in a corridor to the nearest story exit

High-rise buildings should be provided with emergency lighting in all escape staircases, fireman's lifts and its lobby, services rooms, dense-populated areas, escape routes in public buildings and corridors with more than 20 m in length in residential buildings. The horizontal illuminance measured at floor level should be of at least 0.5 lux in intensity. All escape routes and exits should also be provided with exit signs.

6. REGULATIONS IN UNITED KINGDOM

The means of escape and building structure relating to fire safety in UK are governed by two main Acts of Parliament, the Building Act 1984 [14,15] and the Fire Precautions Act 1971 [13]. The former Act concerns about the requirements for structural fire precautions and means of escape while the latter is mainly for fire safety control and issuing Fire Certificates to premises having met the fire requirement [13].

The Building Regulations 1991 is made under the power of the Building Act 1984. There are not any technical details on the requirement. Approved Document B: Fire Safety is, therefore, produced to provide particular details compliant with the Building Regulations.

The Fire Precautions Act 1971, as amended by the Fire Safety and Safety of Places of Sports Act 1987, only applies to specified premises in Order. They are mainly classified into two groups: fire safety at work and at home [13]; and the Fire Precautions (Factories, Offices, Shops and Railway Premises) Order 1989 (SI 1989 No. 76) for factories, offices, shops and railway premises is referred to in this paper.

Approved Document B: Fire Safety applies to England and Wales [12]. The Approved Document is a practical guide compliant with the requirements of the Building Regulations. No definition of high-rise building is found in this Document. But as reviewed [32], high-rise buildings are defined as buildings having the height of 18.2 m and 30.5 m in Scotland, England, Wales Regulations and in GLC Regulations respectively. Purpose groups in terms of the different uses of the buildings are classified in Table D1 in the Document [12]. For some buildings where there may be two or more usages, it is recommended to treat each distinctive use as a purpose group.

- Requirements on Building Structures for flats and maisonettes

Buildings which have a top floor higher than 11 m and have more than three stories above ground level require at least two staircases in order to evacuate occupants to a safe place when a fire breaks out inside any part of the building. Limitations on the travel distance from the dwelling entrance to the common stairs have also been made. Generally, the maximum travel distance should be no more than 30 m in buildings with at least two common escape routes. Common stairs, constructed with fire resisting enclosure, in flats and maisonettes should be at least 1 m or 1.1 m wide if they are also used for firefighting purpose.

Higher fire risks are expected in basement. Therefore, separate staircases should be accessed to the ground level.

- Requirements on Building Structures for buildings other than dwellings

All the components of an escape route should be protected by enclosure with specific fire resistance rating, in order to ensure a safe evacuation of occupants. Escape stairs at higher than 20 m should be connected to the protected lobby and corridor. Generally, 30 minutes fire resistance rating is enough for most cases. In addition, escape stairs serving buildings higher than 20 m should be constructed of limited combustible materials.

The number of escape routes and exits is determined by number of occupants and travel distance limitation. Every part in a story should normally have access to two or more stairs, as shown in Table 4 in the Document [12]. For composite buildings containing various purpose groups, the means of escape serving different purpose groups should be separated from each other. Single escape route is acceptable when the occupant capacity is not more than 50. Buildings with floor level more than 11 m should have more than one escape stairs.

The width of escape routes and exits also depends on the number of occupants. As shown in Table 5 in the Document [12], 50 persons would require escape routes and exits of at least 800 mm wide. From Table 6 in the Document [12], the minimum width of escape stairs is specified. No escape stairs should be wider than 1400 mm if the vertical extent is more than 30 m, otherwise, additional stairs may be desired or a central handrail is needed. All escape routes should have at least 2 m high headroom.

Table 6: Comparison between Fire Safety Codes

	Local codes [2,29-31]	Mainland codes [8-11]	Approved Document B [12]	Fire Precaution Act [13]	GLC London Building Act [14,15]	NFPA 101 [17]	Model building codes [18-24]	CIBSE Guide E [16]
Definition of high-rise buildings	Height ≥ 30 m	Residential buildings ≥ 10 stories. Public buildings ≥ 24 m. Further classified into 2 types.	No definition.	No definition.	No definition.	Height ≥ 23 m	No information.	No definition.
Fire safety measures (provisional requirements)	Depends on usage of buildings.	Depends on the high-rise building type.	Depends on usage of buildings.	All premises.	Depends on usage of buildings.	Depends on usage of buildings.	Depends on usage of buildings.	Depends on usage of buildings.
FRP	Depends on the functions in the building.	Depends on the construction elements of the type of the high-rise building.	Depends on the functions in the building.	Depends on the functions in the building.	Depends on construction elements defined by different materials.	Depends on structural elements defined by different materials.	No information.	Not mentioned.
Compartmentation	Defined by volume.	Defined by area.	Defined by area.	Not mentioned.	Not mentioned.	Defined by area.	No information.	Defined by area.
Number of staircases/exits/routes	Depends on number of occupants in a storey.	Depends on number of fire compartment.	Depends on number of occupants in a storey.	Depends on occupant load and travel distance.	Depends on occupant load and travel distance.	Depends on number of occupants in a storey.	Depends on occupant load.	Not mentioned.
Number and location of Fireman's lift	1 if more than 1 lifts installed. ≤ 60 m from any point of the floor.	Depends on floor area. No prescribed requirements on the location.	Depends on floor area.	Not mentioned.	Not mentioned.	Not mentioned.	No information.	Not mentioned.
Control on HVAC systems in the fire compartment	Shut down in case of fire.	Shut down in case of fire.	Shut down in case of fire.	Not mentioned.	Shut down in case of fire.	Not mentioned.	No information.	Not mentioned.

The travel distance is restricted to different purpose groups with one or more than one exits. For instance, the travel distance in office buildings should not be longer than 45 m if there are more than two escape routes. Limitations on the travel distance are shown in Table 3 in the Document [12].

Normally, the lift could not be part of the escape route since there is a risk where people might be trapped inside. However, under some circumstances, it is appropriate to evacuate people with disability by means of the lift. Lifts should be enclosed by fire-resisting construction in general.

Firefighting shafts including firefighting lifts, firefighting stairs and firefighting lobbies have to be constructed in buildings with a story higher than 20 m above ground or a basement deeper than 10 m below ground. Buildings higher than 7.5 m above ground or having a story of at least 600 m² in floor area should also acquire a firefighting shaft excluding firefighting lifts. It is provided for fire brigade to access and rescue in the building. Buildings without sprinklers installed should provide at least one firefighting shaft for each 900 m² floor area on stories higher than 20 m.

- General requirements on Building Structures for both types

Fire resistance provides three distinctive ways to withstand fire damage. They are loadbearing capacity, integrity and insulation. Details on the fire resistance period of structural elements as well as purpose groups are given in Appendix A of the Document [12].

In general, structural elements within a building deserve 30 minutes fire resistance rating, such as floors, roofs, protected stairways, lobbies, corridors, lift shafts, service shafts, etc. For compartment walls separating different occupancies, 60 minutes standard is needed. From the standpoint of purpose groups, buildings of most of the groups higher than 20 m require at least 60 minutes as specified. Only office buildings with sprinklers provided can have the fire resistance rating reduced to 30 minutes. On the other hand, industrial, storage and other non-residential buildings without sprinkler system have to increase the standard up to 90 minutes.

In addition to construction with fire resistance rating, the interior of building should be divided into smaller compartments so as to confine the spread of fire and smoke in case of fire. Compartment walls and compartment floors, as

defined in the Document [12], should be fire-resistant, and should form a complete barrier to fire between the compartments. For all purpose groups, a wall shared by two or more buildings should be a compartment wall running the full height of the building.

Limitations on compartment area for non-residential buildings are clearly shown in Table 12 of the Document [12]. The maximum floor area of the compartment decreases with the floor height above ground but can be enlarged by the installation of an automatic sprinkler system compliant with the recommendations of BS 5306: Part 2. The maximum allowed compartment floor area can be doubled provided that the building is fitted throughout with an automatic sprinkler system. For office buildings, no limitation is enforced on the compartment area while the maximum area for sprinklered and non-sprinklered assemblies, recreation buildings, shops and commercial buildings are 4000 m² and 2000 m² respectively.

Stairway or any other shafts which passes through more than one compartments should be enclosed in a protected shaft so that the spread of fire from one compartment to another could be delayed.

Fire spread has to be limited not only between compartments, but also between buildings. As a result, the external wall of buildings is required to be constructed of materials of limited combustibility. Where any building is higher than 20 m, or the boundary distance is less than 1 m, the external wall should be constructed in a more stringent way than the reverse case.

- Requirements on Fire Safety Measures

Fire mains used for supplying water to hoses are classified as 'dry' type and 'wet' type. For buildings higher than 60 m above ground, a wet rising mains has to be installed in the building at 60 m level or above, otherwise, both types are appropriate.

Basements tend to be more dangerous than the upper story in case of fire, as smoke and heat would escape through the stairways. It is, therefore, required to discharge the smoke and heat from the basement via the smoke outlets which should be located on the perimeter of the building. The natural smoke outlets should be of at least 2.5 % of the floor area concerned. Mechanical smoke extraction system, as an alternative to the natural one, should provide an extraction rate of at least 10 air changes per hour.

Artificial lighting is critical at escape routes. Locations in different purpose groups requiring escape lighting are denoted in Table 9 of the Document [12]. In addition, every exit to the means of escape should be clearly marked by an exit sign complying with the requirement in BS 5499: Part 1: 1984.

In this Document, no specifications are found on sprinkler system.

7. FIRE PRECAUTIONS ACT 1971

In this statutory instrument, there is no definition made on high-rise buildings. All the requirements are specified for the four kinds of premises: factories, offices, shops and railway premises [13].

- Requirements on Building Structures

Fire resistance period is determinant for fire safety control. The minimum requirement is defined for different construction elements. Most of the elements, including stair enclosure, lift well, escape route enclosure, demand a minimum of 30 minutes. Compartment enclosures in offices and shops premises require 30 minutes while that in factories require 60 minutes. Floors should have a fire resistance period of at least 30 minutes. All these above should be in compliance with all major structural elements having not less than 60 minutes fire resistance rate. In order to achieve the most effective fire resistance, all the service ductwork, pipework openings, etc. should be fire-stopped, or fire dampers are required in ventilation ductwork in large-scale buildings. No requirements are stated on compartmentation size in the instrument.

Generally, there should be at least two stairways in a building. Only low-rise buildings can be permitted to have single stairway. The minimum width of the staircase should be 750 mm. Staircase, being a component of the means of escape, should be separated from other parts of the building by fire-resisting construction and a self-closing fire door. In high-rise buildings, such as factory buildings higher than 18 m above ground level, and offices or shops premises higher than 24 m above ground level, staircases have to be separated by protected lobbies; and so should be the buildings with single stair. More than one staircases should be provided if the travel distance at any point in a basement is longer than the requirement. And normally, staircases from upper floors should not extend continuously into the basement, they should be separated from the ground floor by fire doors.

Fire resistance rating is also required in corridors when the corridor exceeds the travel distance of a dead end and extends to alternative routes, the corridor and junction should be protected by fire-resisting construction. The main corridor should not be less than 1.05 m wide. Moreover, for corridors longer than 30 m in shops or 45 m in factory or office buildings, they should be subdivided by fire doors.

For the rooms in designated buildings, more than one exits should be provided if the room contains more than 60 persons; or if the travel distance to exit exceeds the requirement; or if it is specified as a high fire risk area. The minimum width of such an exit is 750 mm. For an occupant load at 101 to 200 persons, the total width of all exits should be 1.05 m. And then every additional 15 persons require 75 mm more in breadth. The arrangement of the exits in a room is determined by the travel distance and “45-degree” requirement. Routes from any point in a room to the exits should produce an angle greater than 45°.

Travel distance is a pivotal measurement in the means of escape requirements. It affects the number of escape routes and staircases and the dead end length. The maximum travel distance is specified for distinctive fire risk levels in factories, shops and offices and is divergent for one escape direction only and more than one directions. References can be made to the office’s requirement on the travel distance of railway premises. For the fire risk category, factory premises are classified into high, normal and low, shop premises are classified into high and normal, and office premises are considered as normal only. Any dead end existing in the premises should not exceed the total travel distance as specified for one direction only. Details of the limitations are stated in Table 2.

Escalator and elevator are generally not accounted as a means of escape. They should be separated by fire-resisting construction or fire doors from other portions of the building. Elevators can be considered as a means of escape when they are designated for physically impaired persons. At the top of the lift well, an openable vent of not less than 0.1 m² in area should be given for ventilation. Other openings in the lift well are prohibited.

- Requirements on Fire Safety Measures

Fire alarm, either manually or automatically operated, should be installed in all premises. Fire alarm or call points should be installed in accordance with the recommendations of the British Standard.

All the unclear exits should be marked by a “Fire exit” sign. All the escape routes should be illuminated by normal lighting. Escape lighting, capable of lasting for at least 2 hours, should be provided at underground or windowless locations.

8. GLC THE LONDON BUILDING ACTS (AMENDMENT) ACT 1939

New Buildings within inner London is subjected to control under Section 34 of the London Building Acts (Amendment) Act 1939, which is empowered by the GLC [14,15]. The critical height of a high-rise building is 30.5 m, as mentioned earlier [32].

- Requirements on Building Structures

Requirements on fire precautions are divergent to different types of building uses: working, sleeping, resort and others.

Where buildings for working, such as offices, factories, warehouses and similar uses, the width of the escape routes is determined by the maximum number of persons using them. A maximum of 50 persons requires a width of at least 0.76 m and a maximum of 220 requires at least 1.1 m. Every 20 additional persons requires 0.1 m wider. Where at least two exits are required in a building, the two separate exits should be placed remotely from each other and be better located at the extremities of the building to avoid dead ends. In a central-cored office building, the exit stairways should be separated by individual protected lobbies and their direct distance from the ends of the building should not be more than 12 m.

At least two protected staircases have to be provided in a multi-story building. The number of protected staircases would be based on the travel distance requirement and the occupant load. The width of protected staircases should not be less than the width of the exit connected. For buildings having not more than 30 m in height, the stair width should be at least 1.1 m while for those higher than 30 m, the width should be at least 1.4 m. But there is special provision for office buildings having a floor higher than 18 m above ground. For office buildings, the capacity of protected staircases can be increased provided that the staircase is protected by protected lobbies or corridors. The increase of capacity can be achieved by phased evacuation, that means in case of fire, only the floors that fire occurs and the one above have to evacuate. Protected staircases in factories and warehouses should be constructed on the external wall of the building so as to provide openings of not less than 1 m² for ventilation. For

office buildings having a central core, the enclosure of protected staircases should be provided with openings at the top of area not less than 1 m².

In general, staircase from upper floors continuing to the basements should be separated on the ground floor by protected lobbies. More than one exits are required for basement levels if there are more than one basement stories and the direct distance to the final exit exceeds 12 m from any point in the story.

Travel distance, as discussed before, is influential for determining the number or siting of escape routes and staircases. There are two terms relating to the distance measured on a floor. “Direct distance” is a straight line measurement from any point in a story to the nearest exit ignoring any structural elements between them. “Travel distance” is the shortest real route for occupants traveling to the exits. In the requirement, direct distance should not be greater than 30 m and travel distance should not be longer than 1.5 times the direct distance. A self-closing fire door should be provided in approximately the middle of a corridor leading to more than one exits. A dead end should not be farther than 12 m, in terms of direct distance, from the nearest exit.

For leisure premises, such as departmental stores, shops and restaurants, the siting, number and the width of staircases and exits are determined, as for the working places, by direct distance, maximum number of persons occupying and dead end situation. The minimum width of protected staircases should be 1.1 m. The requirements on the number and width of staircases are similar to those for working places discussed above. The minimum width of escape routes and exits from a story is affected by the maximum number of persons served.

Other requirements, including direct distance, dead end limitation, arrangement and number of exits, openable vents in staircase enclosure are identical to those for working places.

For sleeping accommodations, such as those designated for hotels, hostels and boarding houses, most of the requirements are the same with those mentioned above. An additional requirement about the distance has to be complied with. The distance from any point in a bedroom or an inner room of suite of rooms to its room exit door should be no more than 9 m. The inner room could not be a bedroom and if the distance exceeds 9 m, an alternative exit is required for the inner room. The distance measured from the door of the farthest room in a dead end corridor to the nearest exit from

a story or a point leading to multi exits should be not more than 7.5 m.

The requirement of the width of protected staircases is the same as that for the working places. But for buildings higher than 18 m above ground, the protected staircases have to be separated on each floor by a protected corridor or lobby.

Lifts serving bedrooms but connected to high fire risk areas, such as kitchens and storages, should be separated from those high fire risk spaces by a protected lobby. For lifts serving all floors including the basements, they are also required to have a protected lobby where an opening of area not less than 0.4 m² should be provided for natural ventilation.

There are some universal provisions for all the occupancies mentioned above. FRP requirements of 0.5, 1, 2 and 4 hours are specified for different uses of the building according to their volume. There are no requirements on compartmentation in this legislation.

The headroom of an escape route should be at least 2.06 m. All the fire doors should be installed with self-closing devices. Landing at the final exit should not be less than 900 mm in depth in the traveling direction. For a lift shaft, it should be enclosed by non-combustible fire-resisting materials and an opening of area of at least 0.1 m² has to be constructed at the top of the shaft for smoke outlet.

- Requirements on Fire Safety Measures

Fire suppression system, such as hydraulic hose reels and portable fire extinguishers should be sited adjacent to the story exits. For the hose reel, it should not be further than 3 m from the story exit. Portable fire extinguishers should be placed within 30 m from any point in the building to be reached.

Fire alarm system is prescribed to install in compliance with the British Standard. For the manual/electric system, the break-glass call-point should be placed at each story exit and so arranged that it is within 30 m from any point of the building. Automatic fire alarms are required for premises where users are unfamiliar with the environment, e.g., hotel.

Automatic sprinkler is of considerable importance for a building used for storage, trade and manufacture. Its installation should be complied with the British Standard.

Where the mechanical ventilation system is of air-recirculation operation, a smoke detector and an automatic device should be installed together such that in case of fire, the recirculation of air would be stopped and air would be extracted to the outside of the building.

All premises should be provided with adequate artificial lighting so that the occupants inside can be able to move around. In case of failure of artificial lighting, emergency lighting should be provided for a maximum of 3 hours. This kind of emergency lighting is prescribed for all staircases without natural lighting, staircases and corridors in hostels and hotels, and means of escape routes in cinemas and restaurants.

At all the exit doors or openings, obvious exit signs should be provided. The standard size of these notices varies with the distance of observation. When it is seen from a distance shorter than 15 m, the height of the letters should not be less than 50 mm; when the distance is increased to 15-25 m, the letters should not be smaller than 75 mm and at least 125 mm for a distance larger than 25 m.

9. BOCA NATIONAL BUILDING CODE 1996 [18]

- Requirements on Building Structure

The means of escape should be generally protected by fire resisting construction. For corridors, their FRP are based on the use groups and the total capacity of the exits. Corridors in most of the occupancies are required to have 1-hour FRP if there is no sprinkler system installed in the building. But those buildings equipped with sprinklers can reduce the FRP to 0 or 0.5 hour. Openings from rooms facing a corridor should have an FRP or should be a fire door. Corridors should also not serve as return, exhaust or supply plenums of the air-conditioning system. Interior stairway enclosure has to be protected by a 2-hour FRP.

For premises having a floor more than 23 m above ground or a basement more than 9 m below ground, their exit stairways should be protected by a smokeproof enclosure with an FRP equal to or more than 2 hours. Doors on smokeproof enclosure should be self-closing or automatically-closing once actuated by smoke detectors. Ventilation should be provided either by natural or mechanical means.

Horizontal exits leading to area of refuge should be constructed on fire-resisting walls with an FRP of 2

hours. Doorways of them should be installed with a fire door.

No compartmentation requirements exist in the Code.

The required width of means of egress in this Code is based on the total occupant load served. A table of the egress width prescribed per occupant for different use groups having or not having sprinkler system installed is provided. The width of stairways, doors, ramps and corridors can therefore be computed by this table of the Code. Every element of means of egress has its own requirement of minimum width. Corridors should be at least 1.1 m wide for an occupant load of more than 50, but 914 mm is acceptable for an occupant load of 50 or less. The minimum width of stairways is the same as that for corridors. However, doors have to be only 813 mm or more in width. Landing connecting to a staircase should be at least the width of the staircase it served. All these elements of means of egress have a minimum headroom of 2 m.

The requirement on the number of exits is similar to that prescribed in IBC and SBC. For an occupant load of less than 500, at least two exits are required; for an occupant load of 501-1000, three are required and for more than 1000 occupants, four exits should be provided. Single exit is only applicable in low-rise buildings. The requirement on the number of doors for a room or an occupied space is also the same as that mentioned above. If two or more exits are required, any of the two exits should be placed apart remotely such that their distance is not less than half of the maximum diagonal dimension of the building served; or not less than one-fourth of that if the building is sprinklered.

The travel distance is specified for the use groups in which sprinkler system has been installed or not installed. Details are listed in Table 2. Dead end corridors should not be greater than 6.1 m.

An elevator can only be an accessible means of egress in prescription. It can also be an access for firefighters in high-rise buildings.

- Requirements on Fire Safety Measures

Fire detection system, sprinkler system, fire department communication system, standby power, voice/alarm signaling system are required in a high-rise building.

Artificial lighting is required in any part of the means of egress at an intensity of 11 lux at floor

level. Exit signs should be placed at exit doors and exit access areas in buildings having more than one exits. No sign can be placed at more than 30 m from any point in an exit access. Their illumination should be at least 54 lux in intensity. In case of normal lighting fails, emergency lighting should provide illumination for at least one hour afterwards. Emergency lighting in high-rise buildings should be able to operate within 10 s after the primary source loss [19].

10. ICBO UNIFORM BUILDING CODE 1997

- Requirements on Building Structures

All components of the means of egress should be constructed of fire-resistive materials. Corridor walls should have at least one-hour fire resistance rating. Doors in corridors or any exit passageways should have a self-closing or automatic closing device. For windows on the walls of the corridors, they should have 0.75-hour FRP. Any interior openings on the exit enclosure or passage should have specific fire resistance rating as well: for 1-hour rated enclosure, one-hour opening protective rating should be provided while for 2-hour enclosure, 1.5-hour protective rating should be provided for the openings.

Where a wall divides a floor into two or more areas such that it provides certain protection against fire hazards, it should be of at least 2-hour fire protection period. The openings in an horizontal exit which is on such a wall should have 1.5-hour FRP. The horizontal exit should be of either noncombustible or combustible construction according to its type of construction.

There are several construction types classified in this Code [21]. For Type I to V, they are categorized by different construction materials and possess various degrees of fire resistance. Openings on the walls of these types should have their corresponding fire protection ratings.

In this building code, there are no requirements specified on compartmentation size or arrangement.

The width of means of egress in this Code is determined by the occupant load. The specific minimum width is not less than the total occupant load served times a corresponding factor in Table 10-B of the Code. The clear height should normally be not less than 2.1 m. Doors serving more than 10 occupants should be at least 914 mm wide and should have a clear height of 2 m. The landings

connecting to it should be at least 1.1 m measured in the traveling direction. Stairways serving not more than 50 occupants can be of 914 mm wide, otherwise at least 1.1 m wide should be given. The clear height is the same as that for the doors. For corridors, the width requirement is identical to that for stairways. The amount and arrangement of the means of egress required are not mentioned in this Code [20].

The maximum travel distance for sprinklered and nonsprinklered buildings should not be greater than 76 m and 61 m respectively. However, for some occupancies, there are specific requirements. The travel distance limitations are 68 m and 45 m for Group E (Educational) occupancies with or without automatic sprinkler system. Atria, malls and Group H (Hazardous) premises also have their own travel distance requirements. Dead ends should be limited to no more than 6.1 m in length by arranging the exit access.

Elevators and escalators are normally not considered as elements of means of escape. The fire resistance rating of elevator enclosure should be provided according to its construction material.

- Requirement on Fire Safety Measures

Fire alarm should be provided in Group E (Educational), Group I (Institutional), Group R (Residential) and Group B high-rise office buildings [22].

Automatic sprinkler system is prescribed to install in most of the occupancies including Group B, Group E, Group M, high-rise and covered mall buildings.

Smoke detectors should be installed in high-rise buildings, Group I and R occupancies, as specified.

Lighting should be provided at any means of escape at not less than 10.76 lux of illuminance. Exit signs are required to locate within 30 m from any point of the occupied spaces. They can be illuminated externally at 54 lux. Emergency lighting is required to maintain clear vision for 1.5 hours after the failure of the primary power source.

11. SCBBI STANDARD BUILDING CODE 1997

In this code, there are no definitions on high-rise buildings. Requirements are specified for the occupancies classified in the code [23].

- Requirements on Building Structures

Stairways and corridors should be constructed of fire-resistance materials. For staircase continuing downwards to the basement from the upper floor, it should be separated by at least 1-hour fire-resisting construction. In Type I, Type II, Group A-1 and Group I buildings, as well as any building having more than three stories, the exit stairway should be constructed of noncombustible materials. For buildings with a floor higher than 23 m above ground, all exits should be smokeproof enclosure, that means it is of at least 2-hour fire resistance rating.

For buildings installed with air-conditioning system, exit access corridors are prohibited from being the return or exhaust area of the conditioned air.

The width of the means of egress is, as in UBC, determined by the number of occupants served by that egress element. The limitations on the travel distance, dead-end length and width of means of escape for the classified occupancies are listed in Table 1004 in the Code. The minimum width of egress for every occupant is provided and therefore, the number of occupants is the factor of the width of means of egress. However, the minimum width of staircases, corridors and exit doors are prescribed; not less than those measurements can be approved.

The minimum width of the staircases and corridors is 1.1 m for all occupancies, except that for Group E corridors is 1.8 m and that for Group I corridors is 1.2 m. The minimum clear width of exit doors is 0.81 m, as listed in Table 1004, for all occupancies, excluding Group I, which should be at least 0.91 m.

A minimum of two exits should be provided to give access to each occupied area. It is based on the occupant load per story. For an occupant load of not more than 500, two exits have to be constructed; for an occupant load of 501-1000 and more than 1000, three and four exits should be provided respectively. Where there are two or more exits, the two exits should be located as far as possible from each other and the distance between them should be at least half of the maximum diagonal dimension of the area served.

The clear height of the means of egress is 2 m in general.

The number of exits also depends on the travel distance since the maximum travel distance is not greater than 23 m; any path exceeding that limit

should be provided with additional exits. All dead ends should not be longer than 6 m.

Elevators are not regarded as elements of means of egress, but they can be an accessible means of egress for the disabled in some cases.

- Requirements on Fire Safety Measures

The minimum illuminance in the means of egress should be at least 11 lux. Exit signs should be illuminated by at least 54 lux and located no more than 30 m from any point in the exit access. Emergency lighting should be provided so that illuminance of 11 lux in average can be maintained for 1.5 hours. It should be operated no more than 10 s after the primary power has failed.

12. ICC INTERNATIONAL BUILDING CODE 2000 [24]

- Requirements on Building Structures

The fire resistance rating of corridor is prescribed according to different occupancies with or without an automatic sprinkler system. Generally, the fire resistance rating is 1-hour for most of them. Apart from protected by fire-resisting construction, corridors should not be part of the air ducts for supply, return, exhaust and so on.

For buildings having a floor level greater than 23 m above ground, a smokeproof enclosure or pressurized stairway should be provided. Either of them should be provided with 2-hour fire resistance rating.

Horizontal exits connected to separate building parts and refuge areas should have an FRP of not less than 2 hours and fire doors should be constructed on it with self-closing or auto-closing devices which can be actuated by smoke detectors.

As in SBC, the egress width has been specified for each occupant served. The egress width for different occupancies with or without a sprinkler system is listed in the code. For premises without sprinklers, every occupant has to occupy much more space. The total required width is determined by the occupant load.

The minimum width of doors should be 813 mm and that of stairways and corridors should be 1.1 m. But for an occupant load of less than 50, staircases of 914 mm wide can be accepted. The clear ceiling height of them is 2 m. The depth of landing measured in the traveling direction should be identical to the width of the staircases.

The number of required exits is based on the maximum occupant load specified and the limitation of travel distance. At least two exits should be provided if they violated either of the above constraints. They should be so arranged such that the distance between them is not less than half of the maximum diagonal dimension of the building or not less than one-third of that if the building is sprinklered.

The maximum travel distance is exhaustively listed in Table 1004.2.4 of the Code. It is divergent for buildings with or without a sprinkler system. Details are referred to in Table 5. Dead end corridors should not be longer than 6.1 m.

Elevators can only be used as an accessible means of egress rather than a component of the means of escape.

- Requirements on Fire Safety Measures

The means of egress should be illuminated by at least 11 lux in intensity. If the normal power fails, an emergency power system should be ready for operation so that the exit signs can still be lasted for 1.5 hours.

At all exits and exit access doors, exit signs should be provided with at least 54 lux illuminance. They should be placed at no more than 30.5 m from any point in an exit access corridor.

13. NFPA 101 LIFE SAFETY CODE 2000 EDITION

NFPA 101 Life Safety Code [17], published by the National Fire Protection Association, is an American Standard for fire safety. In the latest 2000 edition, it has adopted a performance-based life safety design other than the traditional prescriptive-based option. There, different building uses are classified as different occupancies. The codes are further specified for new and existing buildings.

A high-rise building is defined [17] as a building having a height of more than 23 m measured from the access level for fire appliances to the floor of the highest story. General requirements are provided for all types of occupancies.

- Requirements on Building Structures

Every component of the means of egress should be constructed with certain fire resistance rating. For a space having an occupant load of more than 30, the

connected corridor should have walls of FRP longer than 1 hour separating from other parts of the building.

A smokeproof enclosure should be permitted to protect the escape stair with a fire resistance rating of 2 hours.

Fire compartments are constructed by fire barriers, which provide separation and protection to the building structure. FRP of fire barriers is classified as :

- 2-hr fire resistance rating
- 1-hr fire resistance rating
- 0.5-hr fire resistance rating

Openings, such as fire doors and windows, should be provided for opening protection with specified fire resistance rating. For fire doors, they should comply with NFPA 80 and NFPA 252 and be self-closing. Fire window assemblies should comply with NFPA 80 and NFPA 257. The area of them could not be larger than 25% of the area of the fire barrier. Specifications of opening protective to fire barrier are as follows:

- 2-hr fire barrier -- 1.5-hr opening protection
- 1-hr fire barrier -- 1-hr / 0.75-hr opening protection
- 0.5-hr fire barrier -- 20-minute opening protection

Compartmentation size is diversified in accordance with the different occupancies. For instance, the maximum compartment area of educational occupancies is 2800 m² and the maximum length of the building is 91 m. But for some of the occupancies, such as business and mercantile occupancies, there is no special requirement on compartment size.

The capacity of means of egress depends on the occupant load, which is achieved by dividing the floor area by the occupant load factor specified in the Code. The minimum width of the means of egress should be 91 cm and 71 cm for the new and existing buildings respectively.

However, for door openings in the means of egress, the minimum clear width is 81 cm. And for stairs in the means of egress, 91 cm is only applied where the occupant load is smaller than 50, otherwise, the minimum clear width for stairs should be 112 cm wide.

The headroom of means of egress should have a minimum of 2.3 m and also be not less than two-thirds of the ceiling area of any space.

The number of means of egress is specified as not less than two. For an occupant load between 501 to 1000, three should be provided while at least four should be provided for an occupant load more than 1000.

Where there are two exits or exit doors, they should retain a distance from each other of not less than half the diagonal length of the building.

Travel distance is provided in accordance with different occupancies. New business occupancies, for instance, should have a travel distance to exit of not longer than 60 m.

Elevators are generally not permitted to act as a component of the means of egress, however, it is acceptable, in some circumstances, to be an accessible means of egress for people with disability. Every elevator should have a capacity not less than eight persons. Any elevator travelling a distance more than 7.6 m should serve as a firefighting lift as well. The elevator lobby should be protected by a 1-hr fire resistance rated door.

For people with difficulties in mobility, an area of refuge should be provided at a size large enough for one wheel chair (76 cm x 122 cm) for every 200 occupants and at least 91 cm wide. It should be protected by 1-hr fire resistance rated enclosure.

• Requirements on Fire Safety Measures

A fire alarm system is required to install within buildings in order to signal an outbreak of fire. The manual fire alarm boxes should be located at anywhere no more than 60 m apart from people at any part within one story. It is not mandatory to actuate alarms by the sprinkler system.

The automatic sprinkler system should meet the requirements of NFPA 13 Standard of the Installation of Sprinkler System. They should be inspected, tested and maintained according to NFPA 25.

In respect to lighting, a minimum of 10 lux lighting level should be provided at the floor surfaces within a means of egress. Emergency lighting, as a backup power, should be provided for a 1.5-hr period if normal lighting has been failed. It should provide an initial illuminance at an average of 10 lux and 1 lux for minimum. Tests on its performance should be carried out regularly.

Exits should be marked clearly by an exit sign compliant with the requirements. The exit sign is

recommended to be placed within 30 m from any point of the exit access corridor.

- Additional requirements for high-rise buildings

The following equipments are recommended to install in high-rise buildings:

- a fire alarm system
- an approved automatic sprinkler system with a sprinkler control valve and waterflow device provided on every floor
- a central control station containing control panels
- emergency lighting and standby power

14. CIBSE GUIDE E: FIRE ENGINEERING [16]

This is a useful reference for fire professionals though no definition was found for “high-rise” buildings. Classification by purpose groups is made with reference to Table D1 of Approved Document B [12].

However, some points concerning high buildings have been addressed:

- It is not suitable for high life-risk groups, such as health care premises;
- Protected lobbies should be provided;
- Phased evacuation is more appropriate than widening stairs excessively;
- Firefighting shafts should be provided;
- Protected refuges should be provided.

For residential (dwellings) purpose groups, three sub-groups are given as high-rise, mid-rise and low-rise dwellings. Flats and maisonettes are considered as the first one, in which vertical and horizontal separation become more critical, so that compartmentation and fire-resisting construction should be carefully designed.

- Requirements on Building Structures

The equivalent fire resistance period t_e (in minutes) for enclosed spaces is expressed as follows:

$$t_e = cw_v q \quad (1)$$

where c is a constant dependent on the thermal properties of the enclosing walls; w_v depends on the ventilation openings and q is the fire load density (MJm^{-2}).

The equivalent fire resistance period is correlated with the opening area, the total enclosing surfaces and the fire load density.

The size of the compartment can be doubled if the building is equipped with a sprinkler system. Effective compartmentation is achieved by enclosures with fire-resistance rating, fire stops covering all holes, fire dampers installed with ducts and self-closing fire doors constructed at any openings. The FRP is conventionally acquired by the density of fire load. However, an equivalent fire resistance period determined by the ventilation conditions is considered to be more practical and precise. The ventilation conditions include the size, number and the locations of the openings.

Instead of the prescribed standards existing in the established codes, this Guide provides quantitative assessments to the width of exits. For example, the capacity of a stairway is given by the maximum number of people $N_{in(max)}$ able to enter the stair within a given period:

$$N_{in(max)} = 1.333 W_s t + 3.5 AS \quad (2)$$

where W_s is the width of the stair (m); t is the time available for escape (s); A is the horizontal area of the stair and landings per story (m^2); and S is the number of stories.

In addition, the maximum density of people is assumed to be 3.5 persons m^2 .

The requirements of the number of escape routes are not mentioned in the Guide. It is noted that stairways should not exceed 1.4 m wide if their vertical extent is more than 30 m unless a central handrail is provided. The travel distance is limited to no more than 45 m to the nearest story exit in case of more than one escape routes are available. Lifts are not considered as a means of escape except for evacuation of disabled people in high-rise buildings. For high-rise buildings, it is also more suitable to execute phased evacuation. In this respect, compartmentation should be designed in a cautious manner.

- Requirements on Fire Safety Measures

Hydrant systems are classified into three types including: dry rising mains, wet rising mains and external private hydrants. For buildings higher than 60 m, wet risers must be used in lieu of dry risers, which is, on the other hand, suitable for buildings of height 18 m to 60 m. Each riser should serve no

more than 900 m² floor area and located at 60 m apart from another one horizontally.

Hose reel, as another fire suppression system, is specified in its dimension and spacing and location as well. The hose length is not more than 35 m in common case. Each hose reel serves a maximum floor area of 800 m². All the above firefighting systems should be inspected regularly to ensure they are workable when there is an outbreak of fire.

There are two types of fire alarm systems including break glass manual fire systems and automatic fire detection systems. For the former one, break glass call points should be located anywhere along the escape routes within 30 m people can reach from any part of the building. Certain types of heat and smoke detectors and their siting and spacing are introduced in the Guide [16].

Sprinklers, as a pivotal fire protection system, have to deal with fire hazards divided into light, ordinary and high classes, which is determined by the amount of combustible materials and the speed of fire development. The diversities represent different amount of water required and the maximum area of operation. Specifications are listed in Table 8.1 in the Guide [16]. Spacing of the sprinklers is specified according to LPC Rules: 21 m², 12 m² and 9 m² per sprinkler for light to high hazards accordingly.

Emergency lighting, for use when normal lighting fails, should be located at places shown in Figure 6.7 in the Guide [16]. Exit signs should be located at between 2 and 2.5 m above floor level as given in BS 5499. With regard to the luminance level, a minimum of 0.2 lux and 1 lux are prescribed to defined and undefined escape routes respectively.

15. COMPARISON AMONG ALL CODES

Fire codes in the Mainland, Hong Kong, USA and UK are briefly compared. A summary is shown in Table 6. The following are the key points:

- Mainland codes, local codes and NFPA 101 have explicit definitions on high-rise buildings. The critical height for a building classified as high-rise is 24 m for the Mainland, 30 m for Hong Kong and 23 m for USA; those in UK are 18.2 m and 30.5 m.
- On the classification of high-rise buildings, there are two well-defined types with specified fire safety in the Mainland [8-10]. In contrast, high-rise buildings in other codes and regulations are classified according to their intended usage for determining the fire safety provisions.
- FRP requirements of construction elements are defined according to the classified building types [9] in the Mainland. But an FRP of 2 hours is the basic requirement for construction elements in Hong Kong [29]. Values of FRP might be different and be specified individually for special cases. FRP requirements in Approved Document B and Fire Precautions Act are defined by purpose groups or their intended functions instead of structural elements. However, NFPA 101 specifies FRP for elements of structure according to NFPA 220, in which each construction element is further classified by different materials.
- Building compartments are specified in terms of floor area in the Mainland codes, Approved Document B, NFPA 101 and CIBSE Guide E [9,10,12,16,17], but in terms of space volume in Hong Kong [2]. In all of the places, separation of usage is applied for different compartments. No compartmentation requirements are mentioned in Fire Precautions Act and GLC London Building Act [13-15].
- The required number of staircases is determined by the number of fire compartments in the Mainland [9,10]. The number of persons in a floor is used to determine the required number of exit routes (staircases) in Hong Kong, UK and USA. Nothing is mentioned on the number of staircases in CIBSE Guide E. The required number of staircases is also dependent on the travel distance as prescribed in Fire Precautions Act and GLC London Building Act [13-15].
- The required number of fireman's lifts is determined by the floor area of a storey and a maximum of three are required in the Mainland [9,10]. But the exact locations of the lifts are not specified, only suggestions were made in the codes. In Hong Kong, only one fireman's lift is required in buildings having two lifts [31]. The maximum travel distance between any position in a building and the lift is specified to be 60 m. In Approved Document B, the number of firefighting shafts which contain firefighting stairs, lobbies and lifts is determined by the floor area. Only buildings with a floor higher than 20 m above ground or basement at 10 m below ground should have firefighting shafts

including firefighting lifts. At least one firefighting shaft is required by a floor area of less than 900 m². There is no requirement of firefighting lift specified in Fire Precautions Act and GLC London Building Act [13-15], NFPA 101 [17] and CIBSE Guide E [16].

- As specified in the local codes, Mainland codes, Approved Document B and GLC London Building Act, the air-conditioning and mechanical ventilation system of the fire compartment must be shut down in coordinate operations with the smoke control system [2]. However, it was not mentioned in Fire Precautions Act, NFPA 101 and CIBSE Guide E [13,16,17].

16. CONCLUSIONS

Fire safety codes for new buildings in Hong Kong were reviewed. Comparisons with the fire regulations in Mainland China, UK and USA were made. All these are useful in understanding the present situation on fire regulations for fire safety in high-rise buildings.

In the local codes, prescriptive-based is still the main approach [1]. Minimum requirements based on the size and use of premises are specified. The incremental legislation is developed after each time a big fire had occurred. And the new requirements will be added as an extension to the existing building codes.

It is now argued that the traditional prescriptive-based codes might not comply with economic efficiency and, more importantly, might not give a safe environment when the building is under fire. Therefore, some considerations should be taken into account. Preliminary points of concern are:

- Smoke management aspects [33] should be considered. Smoke can spread rapidly through vertical shafts to various levels of a building. Smoke management system is deemed to be a solution and so it should be studied in detail. For instance, smoke extraction system is essential for an atrium or compartment with large cubical extent. It is a way to confine and remove the smoke such that the spread of smoke and other products of combustion is being controlled. Pressurization of staircases is also suitable for tall buildings, in which staircase is kept clear of smoke by maintaining the air pressures inside the staircase higher than those outside. For the ventilation/air conditioning control system, it should be designed to automatically stop the

induced air movement within the designated compartments.

- Fire behaviour of materials has to be considered. Results measured from fire tests on building materials and products such as the cone calorimeter [34] and the ISO 9705 room-corner fire tests [35] should be referred to. These tests give information on burning materials including heat release rate, flame spread, and their contributions to flashover. They are the modern fire test methods much more suitable than those older flammability standards in assessing new materials and products.
- Implementing engineering performance-based fire codes in Hong Kong [e.g. 36-38] is another solution for dealing with special buildings [39]. For example, operating a sprinkler system in a high headroom atrium will give smoke logging and produce large quantity of steam. The system should not be installed without a careful planning in evacuation.
- Full-scale burning tests should be carried out when necessary. A PolyU/USTC atrium was constructed [40] for performing experimental studies. From which, the actual smoke filling process, transient development of smoke layer thickness, smoke extraction rate, the performance of fire protection design and so on can be achieved.
- Fire safety management should be seriously considered and proposed [28,37,41]. Issuing license to ‘fire safety managers’ of a building or a group of buildings is a solution. A fire safety manager should be appointed to take overall control of the premises and day-to-day safety management of the building. Duties of the building management staffs should be more than ‘locking up’ cars for illegal parking. There should be a maintenance plan, a staff training plan and a fire action plan [42-45]. As restated by the Chief Executive of the SAR government, “life long learning” is the key.

This paper is only a preliminary report on the project. The conclusion is that well-planned studies on fire safety aspect for high-rise buildings [46] must be carried out before implementing regulations.

17. ACKNOWLEDGEMENT

This project is funded under the Area of Strategic Development: Advanced Buildings Technology in a Dense Urban Environment with account number 1-A038.

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APPENDIX A

DEFINITIONS OF TERMS

Accessible means of escape

- A path of travel, usable by a mobility impaired person, that leads to a public way. (section 202 chap. 10 of SBC, USA)
- A continuous and unobstructed way of egress travel from any point in a building or facility that provides an accessible route to an area of refuge, a horizontal exit or a public way. (section 1002.1 chap. 10 of IBC, USA)
- A path of travel, usable by a person with a severe mobility impairment, that leads to a public way or an area of refuge. (3.3.121.1 of NFPA 101, USA)

Balcony approach

- A balcony which is used as an external approach to a common staircase and which serves two or more occupancies. (CoP MoE section 4, HK)

Direct distance

- The distance measured in straight lines along the notional path from any part of a room to the centre of an exit door of the room. (CoP MoE section 4, HK)
- The shortest distance from any point within the floor area, measured within the external enclosures of the building, to the nearest storey exit ignoring walls, partitions and fittings, other than the enclosing walls/partitions to protected stairways. (Appendix E of Approved Document B, UK)
- The shortest distance from any point within the floor area, measured within the external enclosure of the building, to the relevant exit ignoring walls, partitions and fittings other than the enclosing walls/partitions to protected staircases. (3.01.4 of Code of Practice Means of Escape in Case of Fire, UK)

Exit access

- The portion of a means of egress which leads to an entrance to an exit. (section 1002.1 chap. 10 of NBC, USA)
- The portion of a means of egress system between any occupied point in a building or structure and a door of the exit. Components that may be selectively included in the exit access include aisles, hallways and corridors, in addition to those means of egress components. (section 1004.1 chap. 10 of UBC, USA)
- That portion of a means of egress which leads to an entrance to an exit. (section 202 chap. 10 of SBC, USA)
- That portion of a means of egress system which leads from any occupied point in a building or structure to an exit. (section 1002.1 chap. 10 of IBC, USA)
- That portion of a means of egress that leads to an exit. (3.3.61 of NFPA 101, USA)

Exit discharge

- The portion of a means of egress between the termination of an exit and a public way. (section 1002.1 chap. 10 of NBC, USA)
- The portion of the means of egress system between the exit and the public way. Components that may be selectively included in the exit discharge include exterior exit balconies, exterior exit stairways, exterior exit ramps, exit courts and yards, in addition to those common means of egress components. (section 1006.1 chap. 10 of UBC, USA)
- The portion of a means of egress between the termination of an exit and a public way. (section 202 chap. 10 of SBC, USA)
- That portion of a means of egress system between the termination of an exit and a public way. (section 1002.1 chap. 10 of IBC, USA)
- That portion of a means of egress between the termination of an exit and a public way. (3.3.63 of NFPA 101, USA)

Fire door

- A door or shutter, provided for the passage of persons, air or objects, which together with its frame and furniture as installed in a building, is intended (when closed) to resist the passage of fire and/or gaseous products of combustion, and is capable of meeting specified performance criteria to those ends. (It may

have one or more leaves, and the term includes a cover or other form of protection to an opening in a fire-resisting wall or floor, or in a structure surrounding a protected shaft). (Appendix B of Approved Document B, UK)

- A door assembly which if tested under:
 - a) The conditions of test of door assemblies described in British Standard 476: Part 22; or
 - b) The conditions of test contained in the British Standard currently in force at the time of the bringing into use of the premises as a factory, office, shop or railway premises; or
 - c) The conditions of test in the British Standard currently in force at the time the door was manufactured; would satisfy the criteria for integrity for 20 minutes or for such longer period as may be specified for particular circumstances. (Part II in Fire Precaution Act 1971 Guide to fire precautions in existing places of work that require a fire certificate, UK)
- A door and its assembly, so constructed and assembled in place as to give the specified protection against the passage of fire. (section 202 chap. 10 of SBC, USA)
- The door component of a fire door assembly, which is any combination of a fire door, a frame, hardware, and other accessories that together provide a specific degree of fire protection to the opening. (1.4 of NFPA 80, USA)

Fire-protection rating

- The designation indicating the duration of the fire test exposure to which a fire door assembly or fire window assembly was exposed and for which it met all the acceptance criteria as determined in accordance with NFPA 252 or NFPA 257. (3.3.159 of NFPA 101, USA)

Fire resistance construction

- Construction to resist the spread of fire (section 207 chap. 10 of UBC, USA)

Fire resistance period (FRP)

- The period of time for which any element of construction, wall, fixed light, door, fire shutter or other component of a building is capable of resisting the action of fire when tested in accordance with BS 476: Parts 20 to 24: 1987 as specified in tables A to F in the Code. (CoP FRC section 4, HK)
- The period of time from the exposure of an fire to the collapsing of the structure, or a leakage generated for the spread of fire and smoke, or the temperature of the opposite side rises up to 220 °C for any element of construction. (translated from the mainland HR code Appendix 1)

Fire resistance rating

- The period of time a building or building component maintains the ability to confine a fire or continues to perform a given structural function of both, as determined by tests prescribed. (section 202 chap. 10 of SBC, USA)
- The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251. (3.3.160 of NFPA 101, USA)

Fire resisting (or fire resistance)

- The ability of a component or construction of a building to satisfy for a stated period of time, some or all of the appropriate criteria specified in the relevant Part of BS 476. (Appendix E of Approved Document B, UK)
- The construction so designated, including doors, has a minimum standard of fire-resistance of not less than one-half hour in accordance with the relevant Schedules of the current Building By-laws or which achieves such standard when tested in accordance with BS 476: Part 8: 1972 except that, in the case of door(s): (3.01.6 of Code of Practice Means of Escape in Case of Fire, UK)
 - a) the rebates to the door frame or the door stops whichever the case may be are not less than 25 mm deep, and;
 - b) the door is hung on metal hinges having a melting point of not less than 800 °C, and
 - c) the door is rendered self-closing.

Fire-resisting construction

- The ability of a component of a building to satisfy some or all of the criteria specified in British Standard 476, Parts 21 to 24 of the conditions of test contained in British Standard 476 in force at the time of the construction or the bringing into use of the building as a factory, office, shop or railway premises, relating

to load bearing capacity, integrity and, where appropriate, insulation, for not less than 30 minutes or for such longer period as may be required in the case of that construction. (Part II in Fire Precaution Act 1971 Guide to fire precautions in existing places of work that require a fire certificate, UK)

Fire wall

- A 4-hr fire resistant wall, having protective 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. (section 202 chap. 10 of SBC, USA)

Horizontal exit

- A way of passage from one building to an area of refuge in another building on approximately the same level, or a way of passage through or around a wall or partition to an area of refuge on approximately the same level in the same building, which affords safety from fire or smoke from the area of incidence and areas communicating therewith. (section 1002.1 chap. 10 of NBC, USA)
- An exit on a wall that completely divides a floor of a building into two or more separate exit-access areas to afford safety from fire and smoke in the exit-access area of incident origin. (section 1005.3.5.1 chap. 10 of UBC, USA)
- Way of passage from one building to an area of refuge in another building on approximately the same level, or a way of passage through or around a wall or partition to an area of refuge on approximately the same level in the same building, which affords safety from fire or smoke from an area of incidence and areas communicating therewith. (section 202 chap. 10 of SBC, USA)
- A path of egress travel from one building to an area in another building on approximately the same level, or a path of egress travel through or around a wall or partition to an area on approximately the same level in the same building, which affords safety from fire and smoke from the area of incidence and areas communicating therewith. (section 1002.1 chap. 10 of IBC, USA)
- A way of passage from one building to an area of refuge in another building on approximately the same level, or a way of passage through or around a fire barrier to an area of refuge on approximately the same level in the same building that affords safety from fire and smoke originating from the area of incidence and areas communicating therewith. (3.3.61.1 of NFPA 101, USA)

Means of egress

- A continuous and unobstructed path of travel from any point in a building or structure to a public way. A means of egress consists of three separate and distinct parts: the exit access; the exit; and the exit discharge. A means of egress comprises the vertical and horizontal means of travel and shall include intervening room spaces, doors, hallways, corridors, passageways, balconies, ramps, stairs, enclosures, lobbies, horizontal exits, courts and yards. (section 1002.1 chap. 10 of NBC, USA)
- An exit system that provides a continuous, unobstructed and undiminished path of exit travel from any occupied point in a building or structure to a public way. Such means of egress system consists of three separate and distinct elements: the exit access; the exit and the exit discharge. (section 1001.1 chap. 10 of UBC, USA)
- A continuous and unobstructed way of exit travel from any point in a building or structure to a public way, consisting of three separate and distinct parts: the way of exit access; the exit; and the way of exit discharge. A means of egress comprises the vertical and horizontal ways of travel and shall include the intervening room space, doors, corridors, passageways, balconies, stairs, ramps, enclosures, lobbies, horizontal exits, courts and yards. (section 202 chap. 10 of SBC, USA)
- A continuous and unobstructed path of vertical and horizontal egress travel from any point in a building or structure to a public way. A means of egress consists of three separate and distinct parts: the exit access, the exit, and the exit discharge. (section 1002.1 chap. 10 of IBC, USA)
- A continuous and unobstructed way of travel from any point in a building or structure to a public way consisting of three separate and distinct parts: the exit access, the exit, and the exit discharge. (3.3.121 of NFPA 101, USA)

Means of escape

- Structural means whereby [in the event of fire] a safe route or routes is or are provided for persons to travel from any point in a building to a place of safety. (Appendix E of Approved Document B, UK)

- The structural means whereby a safe route is provided for persons to travel from any point in a building to a place of safety without outside assistance. (Part II in Fire Precaution Act 1971 Guide to fire precautions in existing places of work that require a fire certificate, UK)
- A way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out. A means of escape consists of a door, stairway, passage, or hall providing a way of unobstructed travel to the outside at street or ground level that is independent of and remotely located from the means of egress. It may also consist of a passage through an adjacent nonlockable space, independent of and remotely located from the means of egress, to any approved exit. (section 202 chap. 10 of SBC, USA)
- A way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out. (3.3.122 of NFPA 101, USA)

Occupant capacity

- The occupant capacity is defined as follows: (0.38 of Approved Document B, UK)
 - a) Occupant capacity of a room or storey is the maximum number of persons it is designed to hold (where this is known) or: the number calculated (using the floor space factors given in Table 1 [of the Document] by dividing the area of room or storey (m^2) by the floor space per person (m^2).
 - b) Occupant capacity of a building or part of a building is the sum of the number of occupants of the stories in the building or part.

Occupant load

- The total number of persons that are permitted to occupy a building or portion thereof at any one time. (section 1002.1 chap. 10 of NBC, USA)
- The calculated minimum number of persons for which the means of egress of a building or portion thereof is designed. (section 202 chap. 10 of SBC, USA)
- The number of persons for which the means of egress of a building or portion thereof is designed. (section 1002.1 chap. 10 of IBC, USA)
- The total number of persons that might occupy a building or portion thereof at any one time. (3.3.136 of NFPA 101, USA)

Opening protective

- All door assemblies from rooms opening onto a corridor that is required to be of fire resistance rated construction. (section 1011.4.2 chap. 10 of NBC, USA)

Smoke stop door

- A door or pair of doors which when fitted in a frame satisfies the requirements of Section 7 of BS 476: Part 8: 1972 as to free from collapse for not less than 30 minutes and resistance to the passage of flame and hot gases for not less than 20 minutes, and which is fitted so that the clearance between the leaf and frame and in the case of double doors also between the two leaves, is as small as is reasonably practical, and except in the case of doors hung to open in both directions, is provided with a rebate to the door frame or with a door stop, which in either case is not less than 25 mm deep. (3.01.13 of Code of Practice Means of Escape in Case of Fire, UK)

Smokeproof enclosure

- An enclosed stairway, with access from the floor area of the building either through outside balconies or ventilated vestibules, opening on a street, yard or open court, and with a separately enclosed direct exit to the street at the grade floor. (section 1002.1 chap. 10 of NBC, USA)
- An exit consisting of a vestibule and continuous stairway enclosed from the highest point to the lowest point and designed so that the movement of products of combustion produced by a fire occurring in any part of the building into the smokeproof tower is limited. (section 202 chap. 10 of SBC, USA)
- A stair enclosure designed to limit the movement of products of combustion produced by a fire. (3.3.186 of NFPA 101, USA)

Travel distance

- The horizontal distance measured on the floor along the centre line of the exit route between the centre of an exit door from a room and
 - a) The centre of the fire-resisting door to the enclosure of any one staircase;

- b) If there is no such door, the first stair tread of the staircase; or
- c) If the exit route leads directly to a street or to an open area at ground level, any one of the points of discharge to the street or open area. (CoP MoE section 4, HK)
- (unless otherwise specified, e.g. as in the case of flats) The actual distance to be travelled by a person from any point within the floor area to the nearest storey exit, having regard to the layout of walls, partitions and fittings. (Appendix E of Approved Document B, UK)
- (called the Distance of travel) The actual distance that a person must travel between any point in a building and the nearest final exit; or door to a stairway which is a protected route; or a door for means of escape in a compartment wall. (Part II in Fire Precaution Act 1971 Guide to fire precautions in existing places of work that require a fire certificate, UK)
- The actual distance to be traveled by a person from any point within a floor area to the relevant exit having regard to the layout of walls, partitions and fittings. (3.01.15 of Code of Practice Means of Escape in Case of Fire, UK)
- Length of exit access travel measured from the most remote point to an approved exit along the natural and unobstructed line of travel. (section 1006.5 chap. 10 of NBC, USA)
- The distance an occupant must travel from any point within occupied portions of the exit access to the door of the nearest exit. It is measured in a straight line along the path of exit travel from the most remote point through the center of exit-access doorways to the center of the exit door. (section 1004.2.5.1 chap. 10 of UBC, USA)
- The distance from the most remote point in the floor area, room or space served by them to the nearest exit, measured along the line of travel. (section 1004.1.1 chap. 10 of SBC, USA)
- The length of exit access travel, measured from the most remote point to the entrance to an exit along the natural and unobstructed path of egress travel. (section 1004.2.4 chap. 10 of IBC, USA)
- The distance measured on the floor or other walking surface along the centerline of the natural path of travel, starting from the most remote point subject to occupancy, curving around any corners or obstructions with a 1-ft (0.3-m) clearance therefrom, and ending at the center of the doorway or other point at which the exit begins. (7.6.2 of NFPA 101, USA)