EXPLANATORY MEMORANDUM

FIRE SAFETY CODE FOR BUILDINGS

H L MALHOTRA

7-6

Fire Safety Code for Buildings

EXPLANATORY MEMORANDUM

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UNIDO Contract No T81/97
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First draft

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for the

United Nations Development Project for Brazil
(DP/BRA/75/003)
Project Manager
Dr B S Krishnamachar

First Draft

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UNITED NATIONS NATIONS UNIES

PROGRAMA DAS NAÇÕES UNIDAS PARA O DESENVOLVIMENTO
NORMALIZAÇÃO E CONTROLE DE QUALIDADE E CERTIFICAÇÃO
DE QUALIDADE DE FERRO E AÇO (BRA/75/003)

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8 September 1982.

Dear Ten. Cel. N. F. Mattedi,

Further to my letter nº 3221 dated 30 July 1982 I am enclosing a copy of the explanatory memorandum on Fire Safety Code for Buildings prepared by Mr. H. L. Malhotra of Fire Research Station United Kingdom. I hope this will help you in better understanding of the first draft.

Yours Sincerely,

B. S. Krishnamachar
Project Manager
UNIDO BRA/75/003

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CONTENTS

LIST OF FIGURES

Chapter 6 :

Chapter 7 :

CHAPTER 1

INTRODUCTION

The Fire Research Station of the Building Research Establishment in the United Kingdom was contracted by the United Nations Industrial Development Organisation (UNIDO) to prepare a fire safety code for buildings for use in Brazil. The code is intended to provide a model which can be adopted by the Brazilian authorities completely or with some minor modifications for use at state as well as the federal level. The code has been drafted as a set of regulations expressed in mandatory terms to deal with the relevant aspects of the building design. Regulating authorities, architects and designers do not always find it easy to understand the purpose of regulations and methods of implementation without knowledge of the technical concepts on which they have been based. Without a knowledge of fire safety engineering it is not possible to design buildings with optimum fire protection. However, an average designer is not expected to have this specialist knowledge and this explanatory memorandum has been prepared to assist him in understanding the needs and the nature of requirements for fire protection.

The memorandum is not intended as a teaching aid, nor does it claim to deal comprehensively with the total subject of fire protection in buildings. Like the regulations the information it contains is intended for new buildings, however many of the concepts are appropriate for existing buildings where the fire protection measures are found to be inadequate. Precise solutions will require a separate study.

CHAPTER 2

SAFETY OBJECTIVES

Fires create a hazard for the occupants of a building and those in the immediate vicinity, and cause damage to the contents and structure if they are allowed to progress unchecked. Consequently protection against fire has three main objectives,

i) Safety of the occupants,

ii) Protection of the contents and the structure, and

iii) Prevention of fire spread to adjacent buildings.

The emphasis placed on these objectives differs from country to country and between different safety interests in a country. In general the safety of occupants is considered to be the primary concern of the governmental agencies and property protection is usually taken care of by contractual arrangements between the owner or the occupier of a building and his insurance company. However, the demarcation between these objectives is not always clear cut and measures adopted for one purpose will influence the other.

The other concern of the Government is to prevent large-scale disasters caused by conflagrations in which whole areas are devastated and many lives put at risk. In the past such occurrences were caused by spread of fire from building to building. With the advent of tall buildings in urban centres such devastations have been caused in single fires by the uncontrolled vertical spread of fire. Some of the buildings with occupancy levels of 5000 or more represent the level of population at risk in a single district with low rise buildings. Hence the prevention of vertical conflagrations and the safety of occupants in high rise buildings is of special concern for the city authorities.

Some consideration also needs to be given to the safety of firefighters when they enter a building to rescue occupants and to suppress the fire. In addition to the provision of facilities for fire control, the fire brigade need safe areas from which to attack the fire.

CHAPTER 3

TECHNICAL CONCEPTS

Fire safety in a building needs to be considered under three main headings:

i) prevention or avoidance of fire,

ii) protection against fire, and

iii) suppression or extinguishment of fire.

In a code of this type full specification for all aspects cannot be provided, only those items are considered which are relevant to the layout, construction and facilities in a building.

Fire prevention requires measures to be taken so that energy producing or consuming devices are safe in operation, hazardous processes are under control, and restrictions are placed on easily ignitable materials. Electrical systems should be properly installed in accordance with a recognised code of practice; heaters, boilers, cookers, coolers etc should be of good design and well maintained; industrial operations should be carried out safely; and flammable goods kept under strict control. Good housekeeping is an essential part of any fire prevention scheme.

In certain cases additional restrictions need to be placed; for example, the prohibition of smoking in certain public buildings and where flammable gases may be present. In buildings with acute rescue problems such as hospitals control is also desirable on furniture, furnishings and fittings to minimise the chance of a fire breaking out and developing rapidly. Often additional requirements are specified by the authorities concerned to deal with such situations.

It is also important to take measures to prevent contact between a combustible material and a heat source by specifying separation between the two.

Boiler flues, for example, should not have any combustible material in close vicinity where it can be ignited by radiated or conducted heat.

Measures for protection against fire cover a wide spectrum of requirements concerned with the evacuation of occupants, control on the growth rate of a fire, fire containment and structural stability.

The earliest the occupants become aware that a fire has started the more time they have to take action. Automatic fire detection enables an early awareness of fire. This is useful in most buildings but is essential in buildings with large numbers of occupants, or buildings (such as hospitals) where lack of mobility requires more than normal escape times. Linking of detectors with warning devices, and in some cases with door closers, provides additional safety as well as flexibility.

The major influence of the protective measures is in the layout and the construction of a building. The primary concern with life safety requires each building to have adequate means to enable the occupants to move to a place of safety from any part of a building where fire might occur. The concept used relates the escape facilities to the likely risk and provides means for normal occupants to reach the outside of the building, or a protected place inside the building, quickly, provided a fire has been noticed in its early stages. The main factors which need to be taken into account for the design of the escape provisions are distance to a safe place, alternative routes, protected routes, protected stairways and smoke control. From the point of fire the occupants have to move directly to either the outside, as in single storey buildings, or to a safe zone which is part of the protected route. In large or multi-storey buildings staged evacuation has been considered (see Chapter 5). Some of the practical possibilities are discussed in Chapter 6 together with the critical dimensions for the escape routes.

Control on the growth rate of a fire requires the combustible contents to have resistance to ignition and slow burning characteristics, and the exposed surfaces to possess low flame spread characteristics. In addition to control on burning rate and flame spread it is sometimes necessary to ensure that materials do not release excessive heat on their decomposition and only produce limited quantities of smoke. It is not possible to control the nature of contents in buildings easily other than those under the control of public authorities or subject to inspection and licencing. Contents can be controlled in hospitals as they are under strict management and in assembly buildings as they generally require a licence to operate. The proposed regulations do not make any recommendations for this purpose. The control of linings is however possible in most buildings and the regulations have put forward proposals basically for flammability characteristics, except for single family houses. The escape problems in 1 and 2 storey hourse are less severe and the occupiers are unlikely to observe such regulations strictly.

Fire containment and structural stability require the construction to withstand the effects of fire by having fire resistance characteristics and by division into fire compartments. Fire resistance requirements are based on the estimated severity of fire due to the contents and are adjusted to take into account special problems posed by the difficulty of fire fighting and the need to preserve the stability of the structure. Conventionally for each type of building assumptions are made concerning the likely fire load and these are translated into a basic fire resistance requirement for that building type. As the height of the building increases, it becomes important to prevent any collapse of the structure. In a similar way fire resistance requirements for basements are increased due to the difficulty of fire fighting. On the other hand concessions are made for single storey structures due to the ease with which fire control can be exercised.

Fire compartmentation has two aims, to keep certain parts of a building safe from the effects of fire and to control the size of fire. Compartmentation is essential for protected stairways, irrespective of other provisions for fire protection. Similarly all basements should form separate compartments from the rest of the buildings and stairways serving basements should be isolated from those serving above ground floors. In certain types of occupancies where a sleeping risk exists, ie occupants reside on a permanent or temporary basis or where the occupants are not fully mobile, horizontal compartmentation is compulsory, ie all floors are compartment floors. In other cases compartmentation is specified to control the size of the fire.

Another aspect of fire containment is prevention of fire spread from building to building. Where the adjacent buildings are very close to each other, their external walls have to act as compartment walls and prevent fire spread from one to the other. In the boundary condition no openings can be allowed in the facing walls. As the distance between buildings increases the requirements become less onerous and larger window openings as well as combustible materials on the facade can be allowed.

External fire spread can also occur in multi-storey buildings by flames outside windows igniting combustible materials inside. This is a common occurrence in many high rise building fires particularly if the prevailing wind conditions elongate flames emitted from windows. There is no complete solution to the problem but the probability can be reduced by having a vertical or a horizontal barrier between windows, decreasing the size of windows (particularly the width), sealing gaps at floor level with the external wall and prohibiting the use of combustible ceiling linings.

Suppression is concerned with those measures which actively or indirectly permit control of the fire and its extinguishment. The provision of sprinklers, extinguishers, hosereels, hydrants and facilities for fire

brigade to have easy access to the building are the major suppression provisions. Sprinklers are activated by the hot gases rising from the fire and have the effect of extinguishing a small fire which occurs directly underneath and if this does not happen they reduce the severity of fire by reducing the rate of burning of the fuel. Sprinklers have to be properly installed and rules have been made by two internationally known organisations which are followed by most installers. Sprinklers have a beneficial effect on the escape facilities for the occupants and the fire resisting construction. Hence relaxations can be made in requirements for fire resistance of the constructional elements which will benefit from their operation.

Two types of extinguisher systems are possible. Fixed installations for special risks where an automatic, quick response, system is needed, or alternatively portable extinguishers of various types which have to be manually applied to the fire. The portable extinguishers are of some value when used by trained personnel on a small fire. They are of doubtful value on a big fire or when used by untrained people. Their specification in buildings for use by untrained occupants is not being recommended.

Hose reels are useful, as they do not require any special instruction for their operation and have unlimited supply of the extinguishing media. They should be in a prominent place, connected to the water mains, easy to switch on and preferably with a nozzle which can give either a spray or a jet.

The hydrants are primarily intended for the fire brigade personnel and are needed in large and tall buildings where it is difficult to bring in hoses from the outside. In high rise buildings they require to be provided on each floor, preferably near the lobby or the foyer approached by the protected stairway by which the fire brigade personnel will arrive. The connection should be of the type recommended by the fire brigade.

The fire brigade require access to buildings with their appliances and provision must be made at the design stage for sufficient clearance on one or more sides of a building for this purpose. The taller the building the more clearance will be needed for the rescue ladders and hose reel monitors to reach to the highest possible level.

The technical concepts described so far have been translated into 20 fire protection requirements which form the basis of regulations. All of these are not needed for every building and not to the same degree in all buildings. As buildings present different levels of fire risk and have different fire safety needs they have been divided into 14 different types (Chapter 4). However, basements, shopping complexes and high rise buildings because of their special needs are categorized separately.

Figure 3.1 shows the conceptual arrangement of the regulations into three parts,

a) the background information contained in the first three chapters,

b) the design and provision of fire protection measures in Chapters 4 to 9 and Chapter 12, and

c) supplementary advice on management and assessment in Chapters 10 and 11.

The study of (b) is essential for the application of the regulations with Chapter 5 on functional concepts providing the technical basis on which the main design Chapters 6 and 7 are based.

A designer should first of all establish the building type (Chapter 4), and next consider the escape route design (Chapter 6) as well as the general fire protection requirements (Chapter 7), referring to the functional concepts in Chapter 5 if he is not clear of the reasons for any requirement and needs to understand the performance specifications. Both Chapters 6

and 7 make reference to the appropriate standards and codes which provide details of test procedures where these are needed or constructional details as appropriate. The designer should then refer to Chapter 8 for the building type to see if adjustments in the requirements of Chapters 6 and 7 have been made and to Chapter 9 for additional requirements in the case of basements, shopping complexes and buildings of the high rise type, ie more than 8 storeys in height. For example the design of an office building 3 storeys in height without a basement will require reference to Chapters 6, 7 and Section 8.7 of Chapter 8. If, for example, a 20 storey office building has basements and car parking floors, additional reference would need to be made to Section 8.12 of Chapter 8, and Sections 9.1 and 9.2 of Chapter 9.

Figure 3.2 shows a flow chart illustrating some of the essential considerations in the design of buildings and the decision routes to be followed.

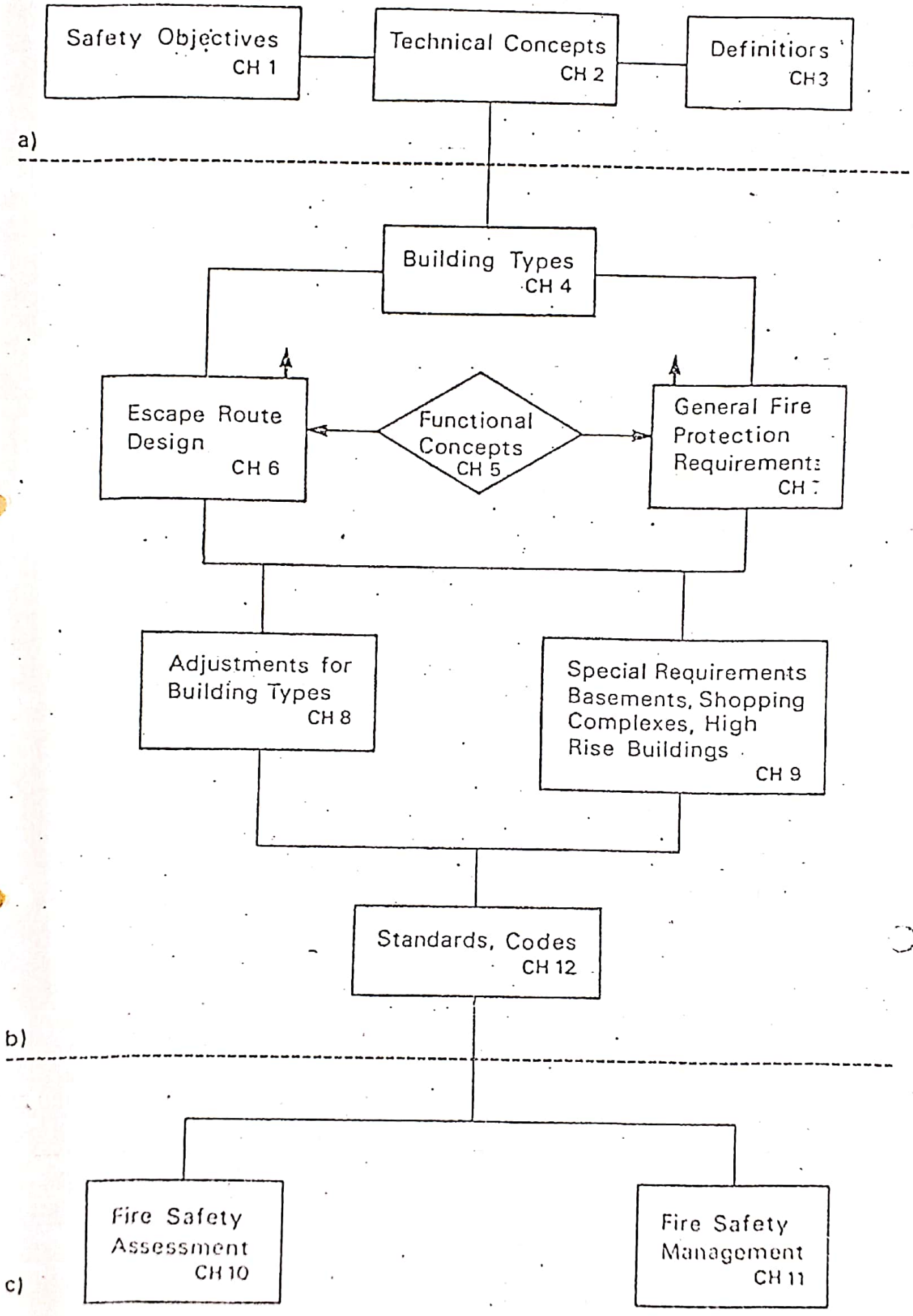

Figure 3.1 The conceptual arrangement of regulations

CHAPTER 4

BUILDING TYPES

Chapter 4 of the regulations divides buildings into fourteen different types on the basis of the expected fire load, occupancy risk factor and hazard due to the use of the building. The fire load indicates the potential combustible material that is available for burning and is generally measured as the calorific value of the fuel per unit floor area. The occupancy risk factor is a composite factor which takes account of the familiarity of the occupants with the building, whether there is a sleeping risk, and the mobility of the occupants. Hazard of rapid fire growth is greater in a department store with openly displaced goods than in a number of small shops selling those products individually. Some of the industrial processes present special risks and it is not the purpose of these regulations to impose additional measures which need to be covered by safety at work provisions. However industrial buildings have combustible products in storage for fabrication purposes, or as an end product, as well as quantities of packaging material which can create a special hazard. On the basis of the fire load, storage buildings represent in general a much higher concentration of combustible materials than other types.

One or two storey houses are treated as a separate category and represent the lowest fire load and in general do not have serious escape problems. Though many people suffer fatal and non-fatal injuries in house fires, there is little that can be done to improve the situation by additional measures. The main need is to educate the occupants to take greater care in the use of cooking apparatus, electrical appliances and smoking materials. Single family houses of three storeys or more have been separated because of difficulty of unaided escape from the top storeys if the staircase is full of smoke. Blocks of flats are dealt with as a separate category, with

similar fire load as the houses but more serious escape problems exist due to numbers present.

Institutional buildings include a large factor of lack of mobility. In hospitals the occupants are usually unable to move without assistance and where they can move their speed of movement is likely to be slow. In prison the occupants may be able bodied but they are not free to move quickly without unlocking of many barriers.

Hotels present a sleeping risk with occupants usually not very familiar with their surroundings. Schools and offices on the other hand have occupants who should be completely familiar with the layout of the building and able to move quickly to the appropriate escape routes.

Shops vary in the degree of risk they present, small shops are relatively safe and hazard exists mainly with large department stores and shopping centres. Department stores have enticing displays of goods and floors communicating by lifts or escalators; whereas shopping centres are usually not high but do have hindrances to free movement. This category also includes restaurants, cafes and bars on the assumption that sales business is carried out in these premises. It is equally possible that some of these buildings would qualify as public assembly buildings.

Assembly buildings vary a great deal in their risk and cover such usages as outdoor games as well as large auditoria and dance halls. The surroundings of some entertainment buildings and their furnishings represent a degree of hazard to the occupants.

Single storey industrial buildings have been separated as representing less of a hazard, but that of multi-storey buildings depends on the number of the work force and the type of activity being undertaken. Car parks are a

special type of storage occupancy where if certain precautions are taken the hazard is small, but for other types of storage buildings account has to be taken of the nature and the quantity of contents. Low fire load storage buildings are those which have a fire load of less than 2000 MJ/m^2 of the floor area.

Buildings which are not explicitly described can be dealt with by analogy on the basis of the factors listed in the first paragraph of this Chapter.

It is possible to have buildings which have designated parts for different usages. Where a complete floor, or floors, are used for different purposes qualifying for a separate building type categorization, such floors should be considered to fall into the appropriate building type and the corresponding requirements apply. For example, if an office building has flats and car parking facilities, although the main category of the building remains Type 7, the other parts should be subject to requirements for Types 3 and 12 occupancies. Where a part of a floor is used for a different purpose, special considerations will apply only if the different use creates conditions of greater hazard, eg a store for flammable goods in the middle of an industrial building.

CHAPTER 5

FIRE PROTECTION MEASURES

General

The technical concepts outlined in Chapter 4 have enabled twenty fire protection measures to be identified. The order of presenting these measures and incorporating them into the regulations has been altered from the initial notion of prevention, protection and suppression. The arrangement which is likely to be more suitable for practical application considers first of all the outside of the building and its location with reference to others in order to reduce the chance of external fire spread. This is followed by considering the growth of a fire inside the building and means to be provided for the safe evacuation of the people present in the building. The design of escape routes is deferred until Chapter 6 for a fuller discussion but smoke control, detection of fire, fire doors, lighting etc are considered in this chapter as factors influencing the means of escape. This is followed by measures for fire containment eg fire resistance, compartmentation, cavities, etc. The last section deals with those aspects which are necessary for fire control and suppression.

The aim has been to give the functional basis or need for each requirement in broad terms followed by a list of factors which should be considered where these can be identified and evaluated. The functional statement is followed by a performance concept and the standard appropriate for achieving the objectives. This is not always possible as for a number of functions no generally acceptable techniques for the determination of performance have so far been developed. In such cases reference is made to constructional details which are acceptable either directly or by reference to a standard, a code or a technical publication which gives the required information.

The constructional references are contained mostly in Chapter 7 which amplifies all the measures in Chapter 5 and specifies how these should be used in buildings. To facilitate direct reference the section numbering is kept identical in Chapters 5 and 7.

Separation between buildings (Figure 5.1)

The purpose of separating buildings from each other is to prevent the spread of fire from one building to another. Fire spread is possible by heat from flames emerging from windows and parts of the external wall having less fire resistance than needed to contain the fire. Heat transmitted from such flames, which may be at a temperature in the range 800 to 1000°C, can under favourable conditions cause combustible cladding to become ignited and combustible materials behind windows to become involved. Problems can also be caused by the burning brands carried by hot gases dropping on the roof of a building. Hazard due to radiation is related to the square of the distance between buildings; no hazard exists from a building having an imperforate fire resisting external wall.

A building under consideration, has to be protected from a fire in an adjacent building and it should not in its turn create a hazard to the other one either. However the rules cannot be applied to an existing building retrospectively and the concept used is that if a building is located at a distance at which it will not create a hazard, it will also be safe at that distance from a fire in the other building.

If there is no existing building it is proposed that the distance should be measured to the boundary and should be half the value of the safe distance. Another building erected at a future date following these rules will keep the proper separation between the buildings.

The assessment of the hazard is based on the amount of unprotected area in the external wall for the whole surface or in the case of compartmented buildings for the largest part which may become a heat radiator in a fire. The unprotected area comprises window openings, walls of less than the required fire resistance, and areas with cladding having lower than Class C flammability grading. Small individual openings, not more than 200 mm^2, are ignored as having no significant influence.

As the ignition of a combustible roof covering is also of concern for separation this is taken into account and the more onerous of the requirements on the basis of wall or roof hazard apply.

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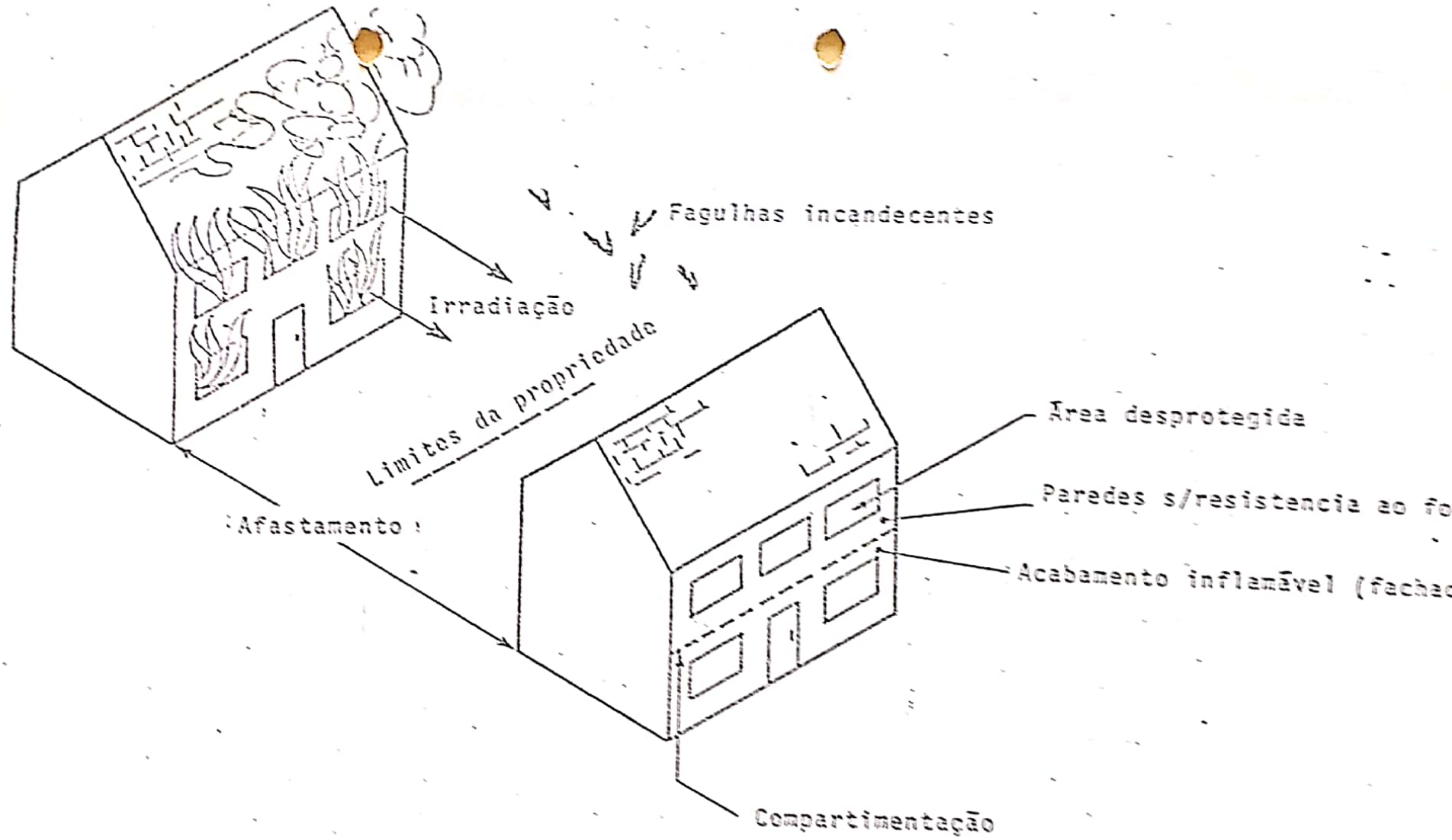


Figure 5.1 Separation between buildings

External enclosures (Figure 5.2)

The external enclosure of a building consists of cladding on the walls and the covering on the roof. Both will be subject to ignition by the radiated heat hence both must be kept a safe distance away. The nature of the cladding will also affect whether or not it will become ignited when flames are emitted from windows below and attack the cladding material. This is of special concern with high rise buildings, hence more stringent requirements have been specified.

Roof coverings of slates, tiles and other non-combustible finishes are safe from ignition hazard but materials of combustible nature need to be considered for their flammability characteristics. For the sake of simplicity the performance of the roof cladding is judged by the same test procedure as the external cladding. However other tests exist which have been specifically designed to examine roof covering materials. A performance specification based on these tests is also possible but a separate test for this purpose should be considered only if there is evidence to show a special hazard of fire spread from building to building by the ignition of the roofing materials.

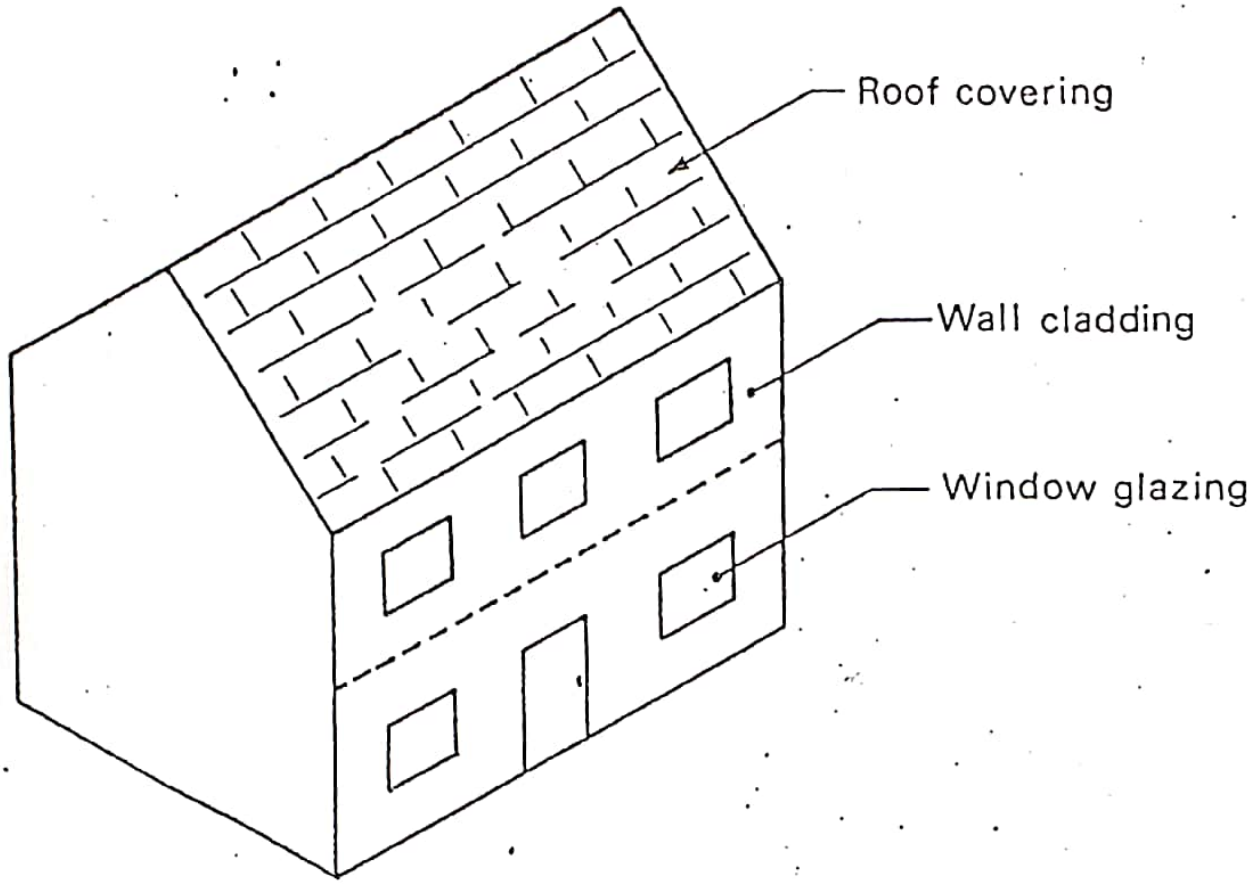


Figure 5.2 External enclosure

Internal surfaces (Figure 5.3)

There are a number of factors which influence the rate of growth of fire once the initial ignition has occurred. If the item first ignited is a combustible content then its nature and closeness to other combustible materials will be the immediate critical factor. After some stage when the environment temperature has been raised and linings have ignited, their rate of burning, flame spread and heat release together with their thermal characteristics will influence the growth rate and the speed with which 'flashover' occurs, ie complete involvement of all combustible materials.

Control on linings is needed in most buildings to delay the growth rate of a fire and provide the occupants with enough time to move to a place of safety. The main characteristics which need to be considered are characterized by the speed of flame spread and the rate of heat evolution. In protected areas designed to provide a safe refuge to the occupants, the linings should be the safest and this also requires a restriction on the production of smoke on their decomposition.

For use in buildings, linings have been divided into three categories, Class A being non-combustible will not contribute to fire, Class B has low flame spread, heat release and smoke producing properties and Class C has low flame spread properties. The building surfaces are also divided into three groups, safe zones eg escape stairways, requiring the best linings, and normal rooms where Class C is acceptable. In between are parts of the escape system eg corridors, and certain buildings requiring higher safety standards eg hospitals, where the minimum requirement is for a Class B lining.

The same method of classification has also been suggested for the external cladding and the roof covering materials, as the discrimination required is similar, but due to the absence of an enclosure the rate of heat release and smoke production are not critical factors, only Class A and C materials have been specified.

Only for Class A materials is an international test specification available, for others various national tests are possible but no precise correlation exists amongst them. Two test systems have been specified, a British and an American one, however the building authorities would need to consider the best way of using these tests together or in conjunction with some other tests.

It is also important to ensure that test data are obtained on representative samples - where the material used is a composite product and more than 25 mm in thickness, it should be sufficient to test a 25 mm thickness, unless a major proportion of this consists of thermoplastic polymers when a full thickness would be needed for test purposes.

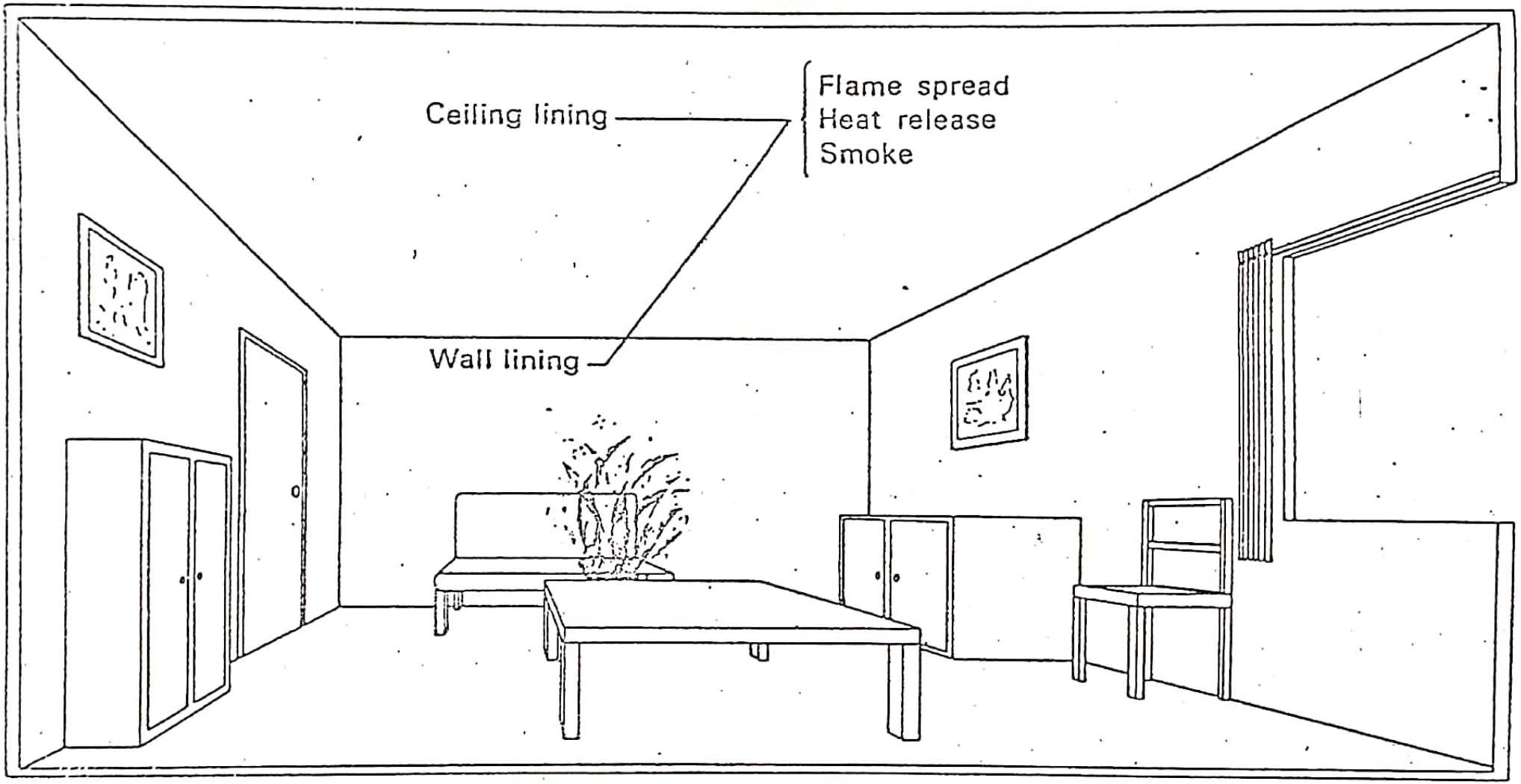


Figure 5.3 Internal surfaces

Means of escape (Figure 5.4)

The provision of means of escape in multi-storey buildings is perhaps the most important consideration for life safety and has a significant effect on the internal layout of the building. The prime objective of escape provisions is to enable the occupants to get to the outside of the building from any point where they may be present, generally unaided and without reliance on external rescue. Lifts should not be used except under direct supervision of the fire brigade for the evacuation of those with a mobility handicap. Large and complex buildings require much greater time for full escape to be realised and therefore evacuation in stages has to be considered. Firstly there is the movement from the fire zone to an unaffected area, which may be a corridor; secondly the movement to a protected area in which the occupants are safe from the effects of fire; and thirdly movement in this zone to the outside through a final exit from the building.

Means of escape require the proper design of escape routes and other measures to keep them tenable for as long as needed. Numerous factors need to be taken into account and these have been divided into two groups, those concerned with the design of escape routes, dealt with in Chapter 6, and others to maximise their use which are discussed in this chapter.

Properly designed escape routes can be used not only by the occupants to make their way out of a building but they are also useful for the fire brigade personnel to be able to enter the building for rescue and fire fighting purposes. Provisions are made, where considered necessary, for part of the escape system to be specially protected and earmarked for fire brigade use.

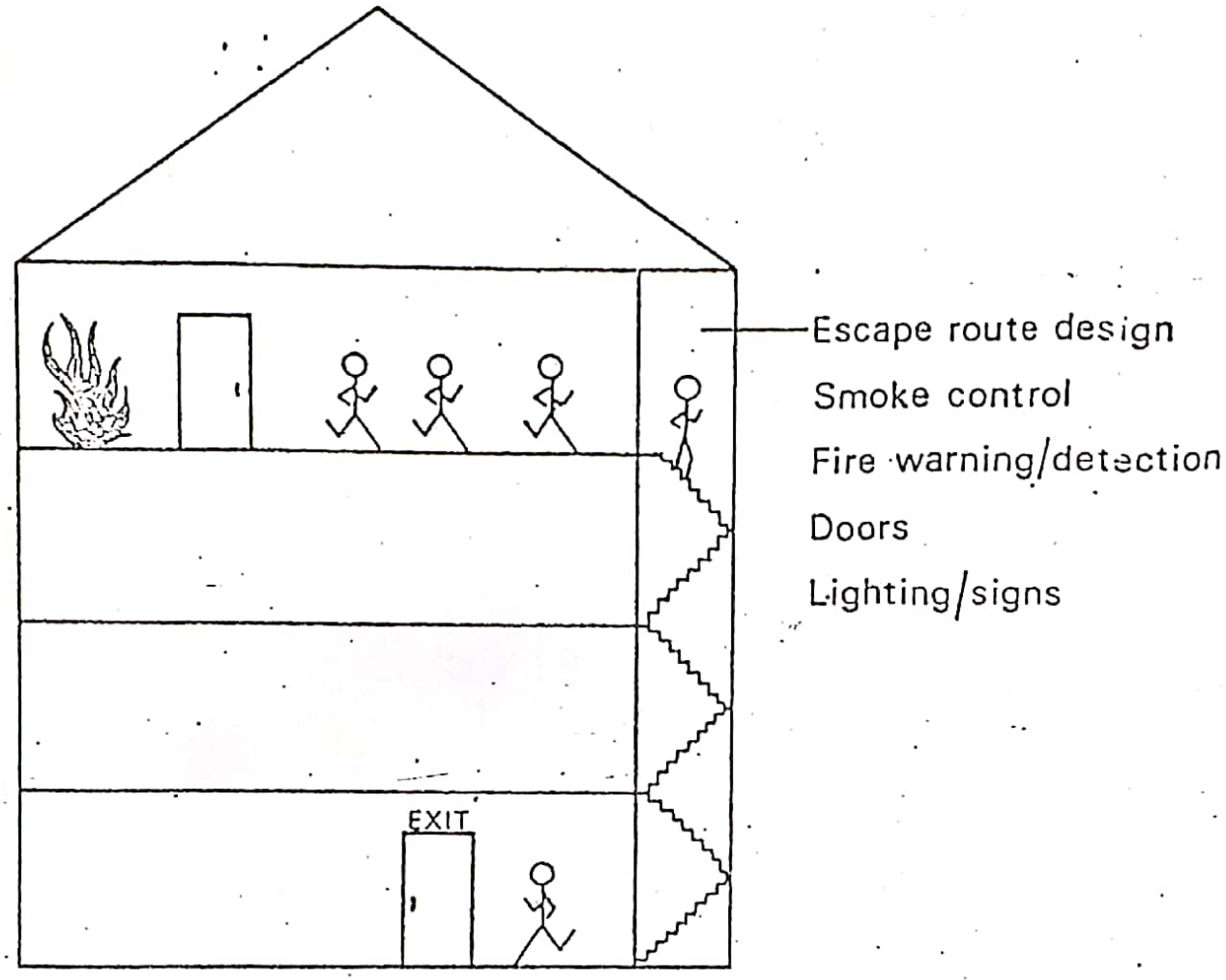


Figure 5.4 Means of escape

Smoke control (Figure 5.5)

Smoke is one of the undesirable by-products of a fire and can seriously interfere with the movement and escape of occupants. The usefulness of escape routes can be nullified if smoke is able to collect in these areas and cause difficulties for the escaping occupants and, in the extreme case, make their use impossible. Consequently provisions are made to keep the escape routes clear of smoke to such an extent that the occupants can make their escape in safety. The simplest measure that can be taken to control smoke movement is to erect doors of suitable type at selected points of the escape route. Such doors are termed smoke control doors and can at the same time possess fire resistance although not all fire resisting doors are automatically good smoke barriers as discussed in the section on fire doors. Smoke control doors do not provide a perfect barrier to smoke transfer, they could also be left open particularly where occupants are escaping from a fire zone and hence at some stage smoke will enter parts of the protected routes.

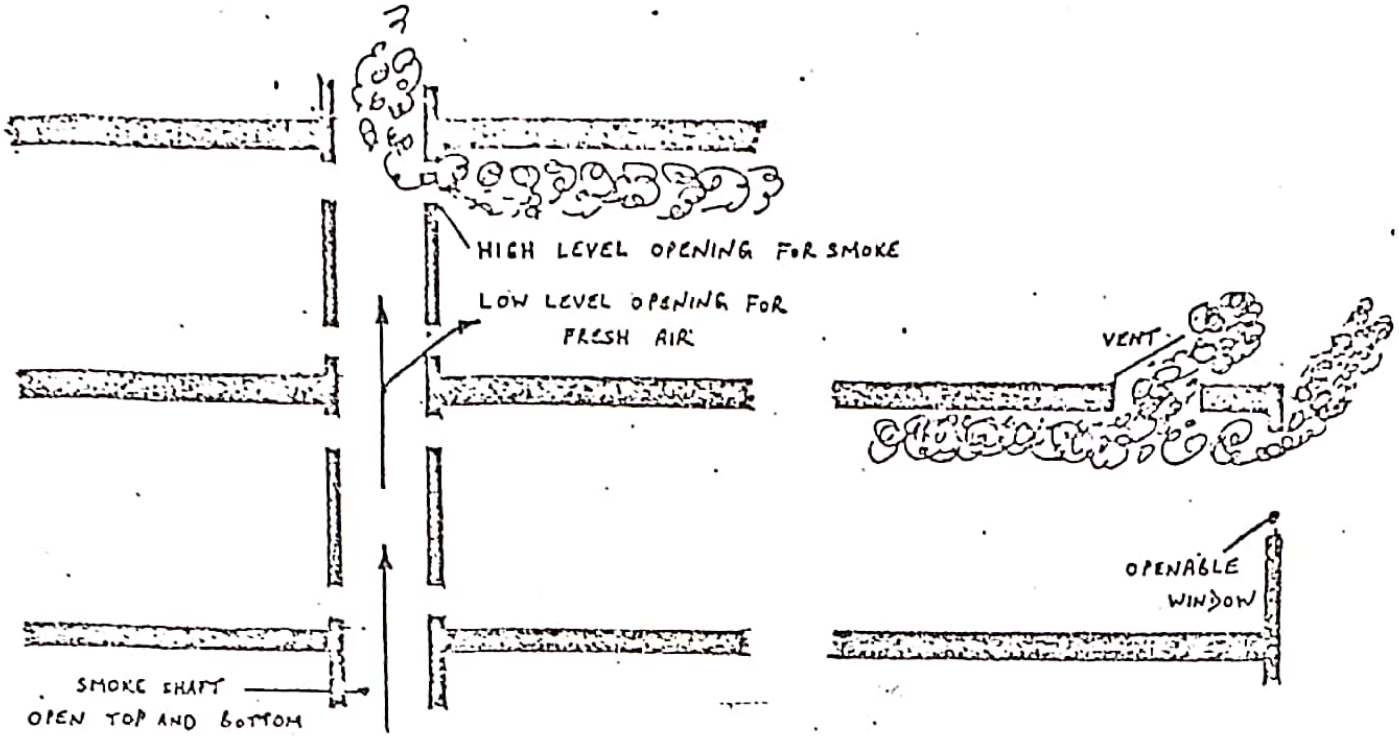
In addition to smoke doors it is possible to introduce additional measures and these function in two different ways, either by the removal or dispersal of smoke which has collected or by the prevention of smoke entry by pressurization of the area. Smoke removal is possible by the use of natural ventilation or by forced extraction. The use of openable windows and permanent openings across corridors rely on natural ventilation to clear the smoke. The reliability of such systems is low and under adverse weather conditions no smoke may escape.

In multi-storey buildings special smoke shafts can be provided, these are vertical ducts with openings at different floor levels near the ceiling.

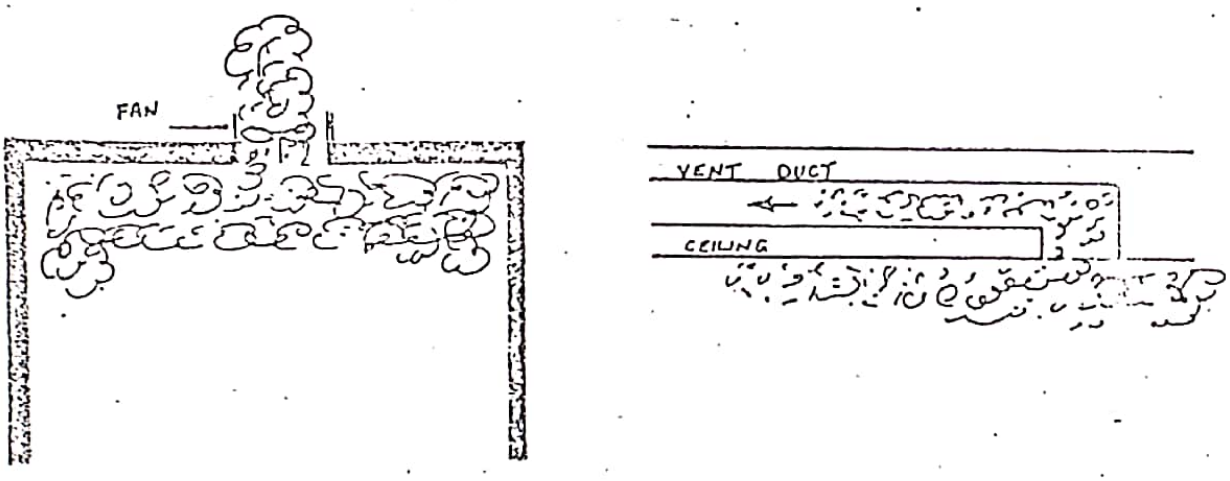
The ducts are open top and bottom so that flow of air occurs in an upwards direction due to buoyancy effects. Smoke in a fire area will collect near the ceiling and will be drawn out through the opening which should ideally remain closed under normal conditions, and open when a fire occurs. It is also useful to have a provision for the supply of fresh air at low level to replace the extracted smoke. These systems have greater reliability but the efficiency may not be high and benefits restricted to small areas. Mechanical extraction has much higher efficiency and systems can be designed to deal with any given smoke clearance problem.

Pressurization is also a mechanical system with a high level of efficiency and works in reverse by forcing the air in the pressurized areas to move in a direction opposite to smoke flow and thus prevent its entry into such areas. Pressurization of stairways in office buildings and hospitals has been successfully achieved.

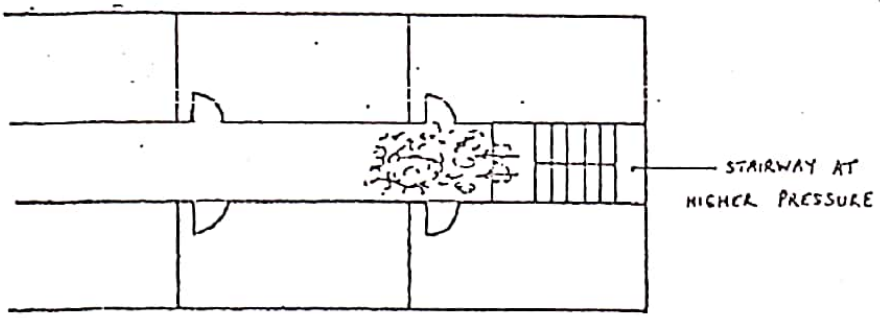
Other than escape routes, some general areas in buildings also require consideration to be given for smoke clearance, particularly where an air tight enclosure is provided for purposes of air conditioning. Some provision for openings in an emergency needs to be made. Ventilation and ducted systems can assist spread of smoke from one part of a building to another. Means should exist to shut-down ducted air supply and extraction systems when a fire occurs and smoke enters the ducts, or alternatively to divert smoke to the outside of the building.



NATURAL VENTILATION



MECHANICAL EXTRACTION



PRESSURIZATION

Figure 5.5 SMOKE CONTROL

Fire warning systems (Figure 5.6)

Early awareness of fire is of paramount importance if the occupants are to make the maximum use of the escape provisions and attempts are to be made to control the fire. Fire detection and fire warning systems are essential for this purpose particularly where a sleeping risk is involved, the occupants are present in large numbers, the building layout is complicated, and occupants need assistance for their escape.

Fire warning systems have the main function of informing pre-selected recipients of the occurrence of a fire. These may be the occupants of a building on a given floor or throughout the building, the management of the building and the fire brigade either directly or through a subsequent message.

The fire may be noticed by an individual and he should have access to a switching system, usually a 'break glass' call button mounted on the wall, which when pressed operates an audible warning system in that part of the building and simultaneously gives an audible or visual warning at some central control point. In small establishments use of a bell or other sound producing device may be adequate. In buildings where a fire detection system is installed the warning shall be given automatically when a detector senses a fire.

The warning signal should be clearly understood by the occupants, and buildings with transistory occupants, eg hotels, require clear notices for this purpose. The operating switches should be located in a prominent position, close to a fire door, stairway or some other safety provision eg an extinguisher or a hosereel. Whilst the switches need to be protected against misuse, the protection should be easily removable by simple mechanical

means. The sound produced should be distinctive, clearly audible above the background noise and not be confused with any other warning system. Visual systems consisting of special flashing lights may be appropriate in special occupances such as hospitals and theatres. In large buildings it is possible to include in the fire warning system a public announcement facility to inform the occupants of the occurrence of a fire and to guide them to a place of safety.

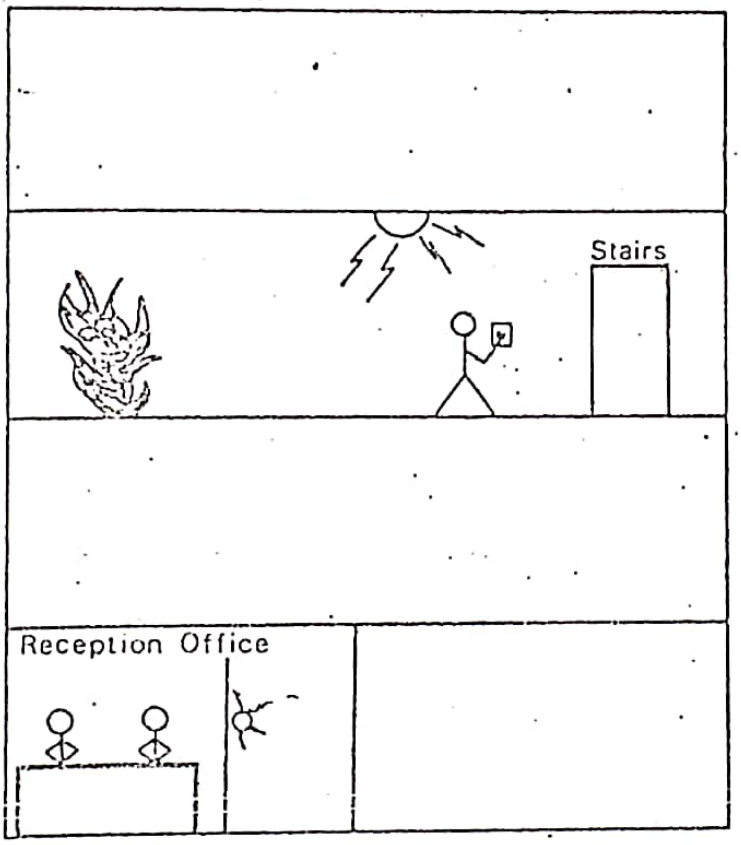


Figure 5.6 Fire warning system

Fire detection (Figure 5.7)

In occupied areas of buildings human detection of fire should be quick if the occupants are not asleep or unfit. Once a fire has been noticed the correct action is to inform the management, other occupants of buildings and the fire brigade before attempts are made to fight the fire. Automatic detection of fire overcomes these deficiencies and provides the possibility for taking a prompt action for the control of the fire and the rescue of people. There has been concern with the rate of false alarms which some detection systems are prone to, however new developments in which detectors become part of a general surveillance and control system for the building with the possibility of continuous monitoring with the aid of micro-processors have considerably increased the level of reliability.

Four main types of detectors can be used in buildings,

a) Optical type smoke detectors which respond to the presence of smoke due to its light scattering or light obscuration properties.

b) Ionization type smoke detectors which contain a small radio-active source ionizing the air within the detector and allowing a small ionization current to flow. The presence of smoke causes this current to reduce, allowing the detector to respond. These are more sensitive to certain types of smoke than type a).

c) Infra-red or ultra-violet sensitive flame detectors which respond to the emission of infra-red or ultra-violet rays from flames and are principally of interest in industrial locations where they can be mounted at a high level and the sensing head can monitor a large area, and

d) Heat-sensitive detectors which respond to the temperature of the gases from a fire collecting under the ceiling, rising either above a predetermined level (fixed temperature detector) or faster than a predetermined rate (rate of rise detector).

Fire detectors respond to the occurrence of a prescribed phenomenon and require to be connected to a fire warning system to make people aware of the occurrence of a fire. The type of detector to be used depends upon the likely source and type of fire and advice is given in the appropriate standards for making the choice. The positioning of detectors is also critical and the location selected must be sensitive to the accumulation of smoke and hot gases, obvious stagnant areas should be avoided.

Signals from detectors can be fed to control systems for the operation of specified protection measures eg doors held open by electromagnetic devices can be automatically closed when fire is sensed in their vicinity. Where a central control room is provided in a building the detector message can be used to locate the point of fire and after immediate verification the message can be transmitted to the fire brigade.

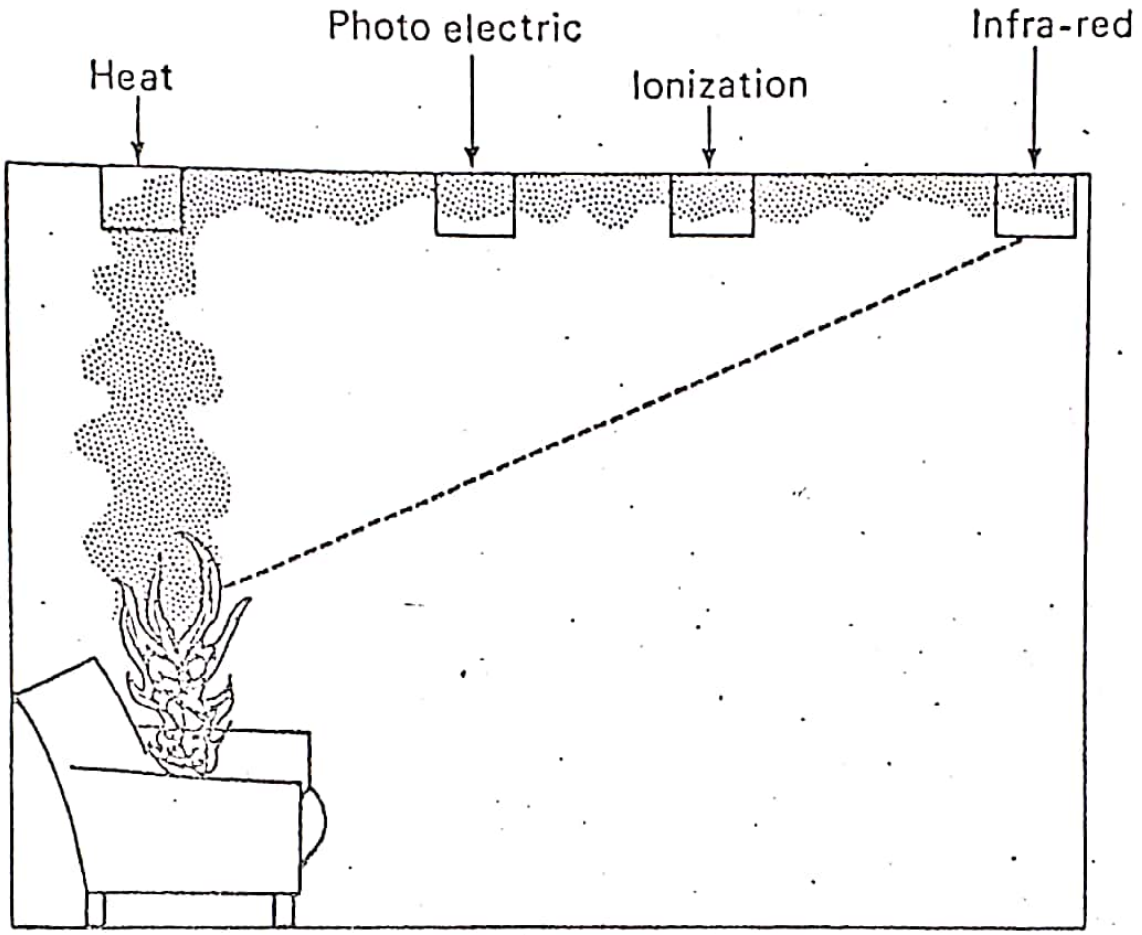


Figure 5.7 Fire detection

Fire doors (Figure 5.8)

Fire doors have two functions to perform, to control the movement of smoke and to prevent the passage of hot gases and flames. The first type is known as smoke control and the second as fire control or fire resisting. In many situations in buildings both functions need to be satisfied by the same door.

Standard tests are available to determine the fire resistance of doors, ie their ability to fulfil the second function, but tests for smoke control doors have not been fully developed at present. The ability of a door to resist smoke penetration is dependent upon sealing of the door edges; seals which may be appropriate at low temperatures, eg plastics foams, may not be adequate at high temperatures. There are also seals made of intumescing materials which operate at high temperatures but provide no protection against smoke leakage at the lower range of temperatures. Where it is necessary to resist smoke penetration over the whole range of temperatures both types of sealing systems need to be incorporated. In the absence of a performance specification for smoke control doors, no distinction has been made in the regulations and all doors are referred to as fire doors.

Fire doors are judged for their effectiveness on the basis of the of the standard fire resistance test used for walls and partitions. The same criteria are applicable although in practice relaxation is made for the insulation requirement on the assumption that combustible materials are unlikely to be placed against or attached to a door. Certain fire doors require to be provided with vision panels, these should be made of wire reinforced glass or other special glazing which can withstand exposure to high temperatures without breaking or melting. Proper fixing of glazing is also an important consideration otherwise localized weakness can permit

fire penetration. Special glazing units are available, consisting of a laminar construction, which have the capability of providing insulation as well as acting as a barrier to the passage of flames.

On the occurrence of a fire, if a door is not closed it will not be able to provide the protection for which it has been designed. It is therefore important that means are provided for keeping the fire doors in a closed position or closing them automatically if they are held open or left open. Various types of door closers are available, the simplest consisting of rising butts which are not recommended other than in domestic buildings. Mechanical door closers fitted to the head of the door or at sill level can be used and where the door does not have a latch to hold it shut the closer must be capable of retaining the door shut even when exposed to fire temperatures. Doors which need to be kept open during the normal use of a building can be held by electro-magnetic or other devices which should be linked to a manual or automatic release system to close them on the occurrence of a fire or when the building is not occupied. Devices are also available which provide free swinging facility for the door during its normal use but have a built-in sensor to automatically close the door when a fire occurs or a signal is given.

The force required to open a door against the pressure of the closing device should not be excessive, special attention needs to be given to doors provided in schools, hospitals, nursing homes etc. All exit doors must be unobstructed and easily openable by those escaping. Doors in places of assembly may need to be fitted with emergency release devices such as panic bolts and these must be easy to operate.

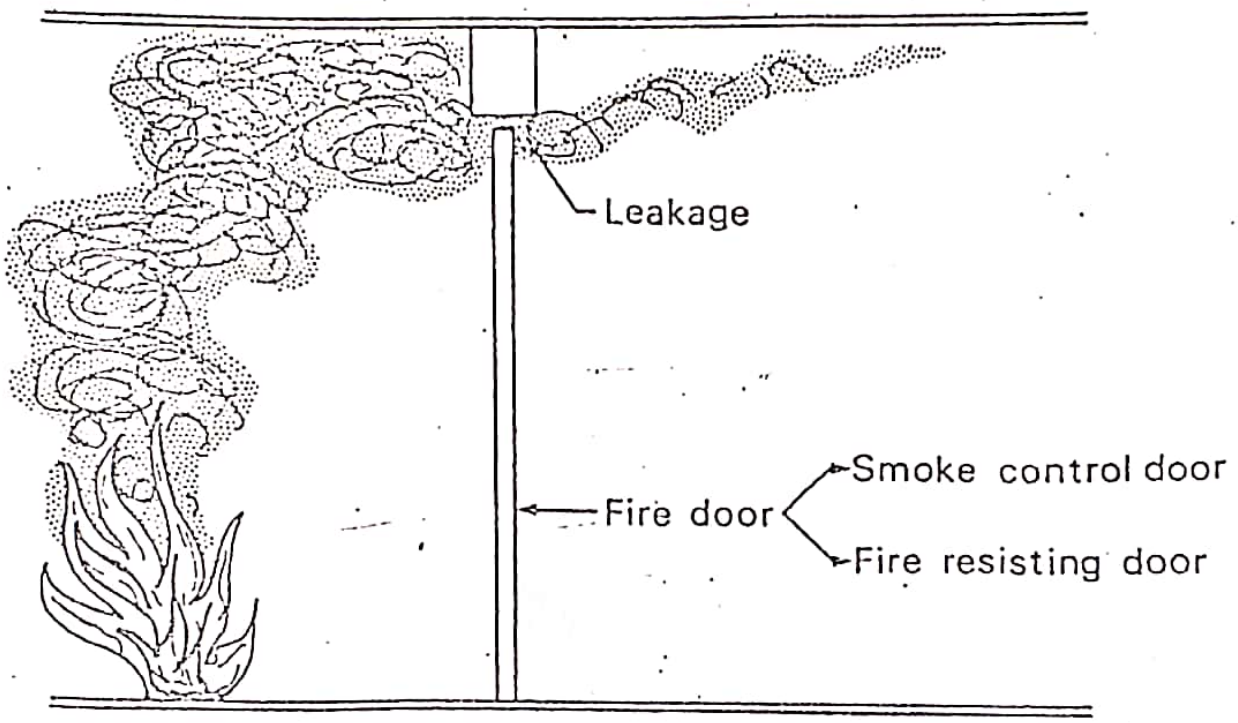


Figure 5.8 Fire doors

Lighting (Figure 5.9)

The occupants of a building need to be able to see their way to the exits provided for their use in case of a fire. Adequate lighting of such routes is therefore an essential requirement; reliance cannot be placed on daylighting alone. Artificial lighting should be provided which is available whenever the building is occupied. The lighting level should be such that the occupants have no difficulty in finding their way from any part where they may be present.

In addition to normal lighting, emergency or safety lighting shall be provided in most buildings to provide illumination in the escape zones so that occupants can use these in case the normal lighting fails. The escape lighting should either be on continuously or come into operation automatically when the normal lighting fails. The lighting may be of maintained or non-maintained type and may use separate circuits of a protected nature able to withstand exposure to high temperatures. Safety lighting should illuminate alarm call points, fire fighting equipment and emergency safety signs which direct occupants to a place of safety. In large buildings standby batteries or generating sets are needed for emergency lighting purposes.

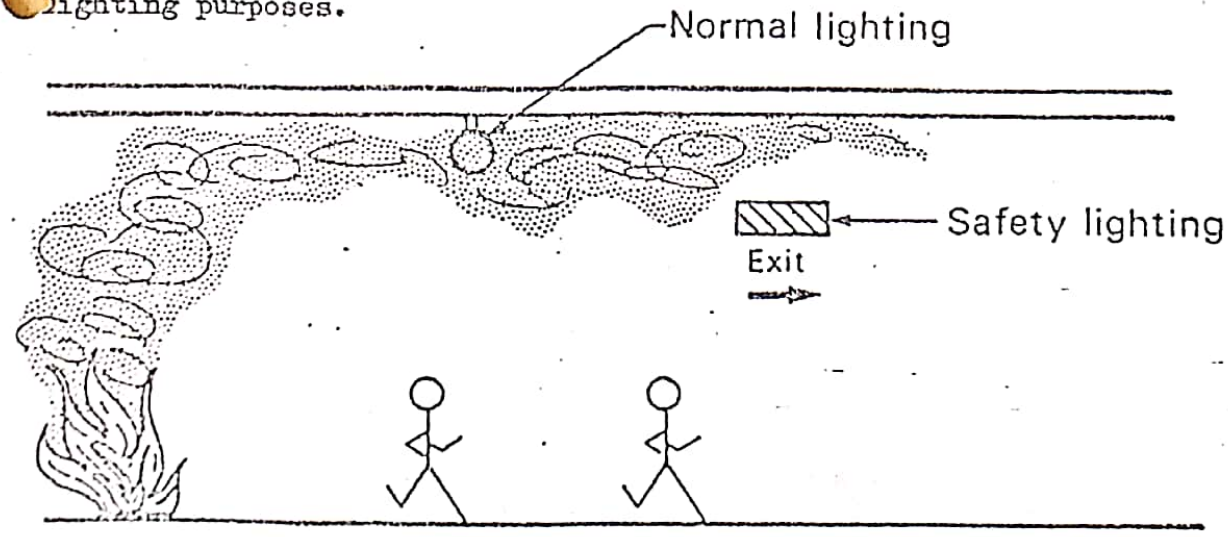


Figure 5.9 Lighting

Signs (Figure 5.10)

Signs should be provided in buildings for the information and guidance of the occupants. Their purpose is to prevent careless action leading to a fire, give guidance on good practice, and actions to be taken in an emergency. There are five types of signs which can be used for fire protection.

a) warning signs to inform of danger, eg the existence of highly flammable or explosive materials,

b) fire equipment signs indicating the location of extinguishers, call buttons, etc,

c) emergency signs indicating escape routes, exits etc,

d) prohibition signs preventing activities which might lead to fire eg no smoking in certain areas, and

e) mandatory (obligation) signs which require certain positive actions to be taken eg fire door keep shut.

Signs are usually present in three different ways, one or two words close to the subject of information eg 'exit' over doorways, 'fire door' label attached to doors, a symbol eg arrows with or without a symbol to indicate the direction to be taken, and a detailed notice which has to be read to understand the safety information it contains. The language used on a sign should not be a barrier to its understanding.

Signs should be brief, easy to follow and located prominently. They may need to be illuminated to improve their visibility.

Special problems exist in areas which contain advertising of various types with and without illumination, shopping areas represent a particular situation where safety signs may not be noticed, and special care is needed in their design and presentation. The authorities may need to restrict other signs in the vicinity of safety signs.

The location of signs must also be considered carefully, signs which are expected to be used during a fire may need to be repeated at low levels to prevent their obscuration by smoke. In assembly buildings and hotels arrows on the floor leading to an exit have been suggested.

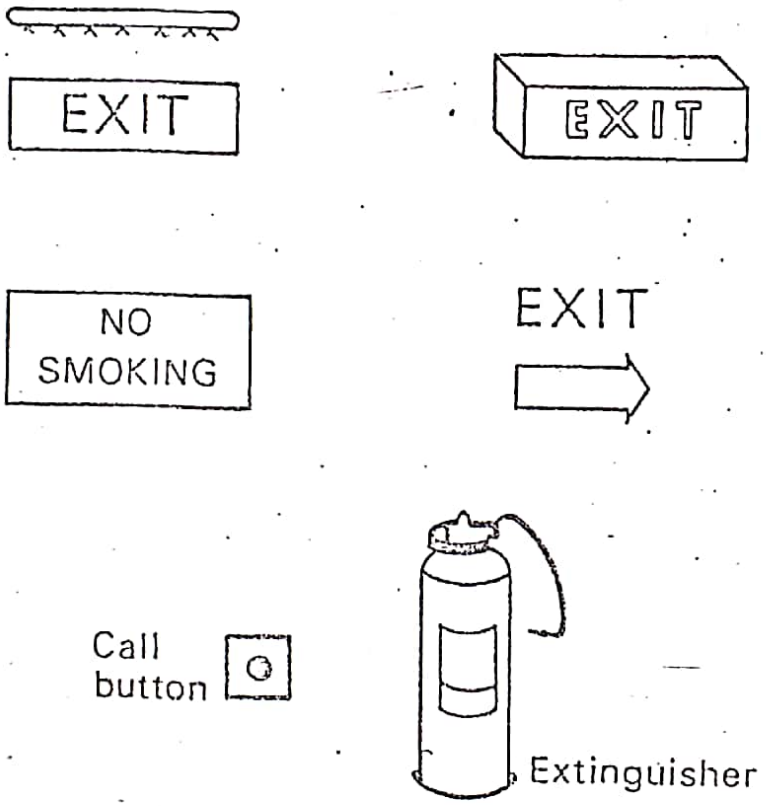


Figure 5.10 Signs

PM & EB.

Compartmentation (Figure 5.11)

There are two main purposes of compartmentation, one to contain a fire within fire resisting boundaries to safeguard occupants in other parts and secondly to enable the fire brigade to bring the fire under control. For this purpose the building should be divided into cells, each designed to withstand the burn-out of contents expected to be present. Theoretically the fire should not go beyond the boundaries of a single compartment, in practice however fires do manage to penetrate compartment boundaries through weaknesses introduced by the presence of doors, passage of pipes, ducts etc through the boundaries and by the transfer of fire over the facade of a building. It is therefore important that the effectiveness of compartment walls and floors is not negated and requirements are specified in the regulations to deal with these weak areas. The protective measures should ensure that doors in compartment walls have the same fire resistance and fire penetrations are sealed and protected. The external spread of fire cannot be entirely prevented, however the possibility can be minimized by the introduction of certain measures, such as vertical or horizontal barriers between windows and low flammability of linings next to window openings.

The regulations specify compulsory compartmentation for all protected escape stairways and protected lobbies. In building type 3, each flat is treated as a separate compartment; in hospitals and hotels every other floor is required to be a compartment floor; however for high rise buildings (> 8 storeys) all floors must be compartment floors. The purpose of this compulsory compartmentation is to retain the viability of escape stairways in multi-storey buildings, to protect householders from

acidentais incêndios vizinhos, e prover de tempo adequado para o

their neighbour's accidental fires, and to provide adequate time for the
controle e o extermínio do fogo. Concessões nos tamanhos de compartimento são
control and extinguishment of fire. Concessions on compartment sizes are
permitidos quando meios automáticos são fornecidos para controle do fogo por
allowed when automatic means are provided for fire control by sprinkler
instalações de sprinklers, afim de reduzir a chance de um incêndio vir a
installations as this reduces the chance of a fire becoming large.
tornar se de grandes proporções.

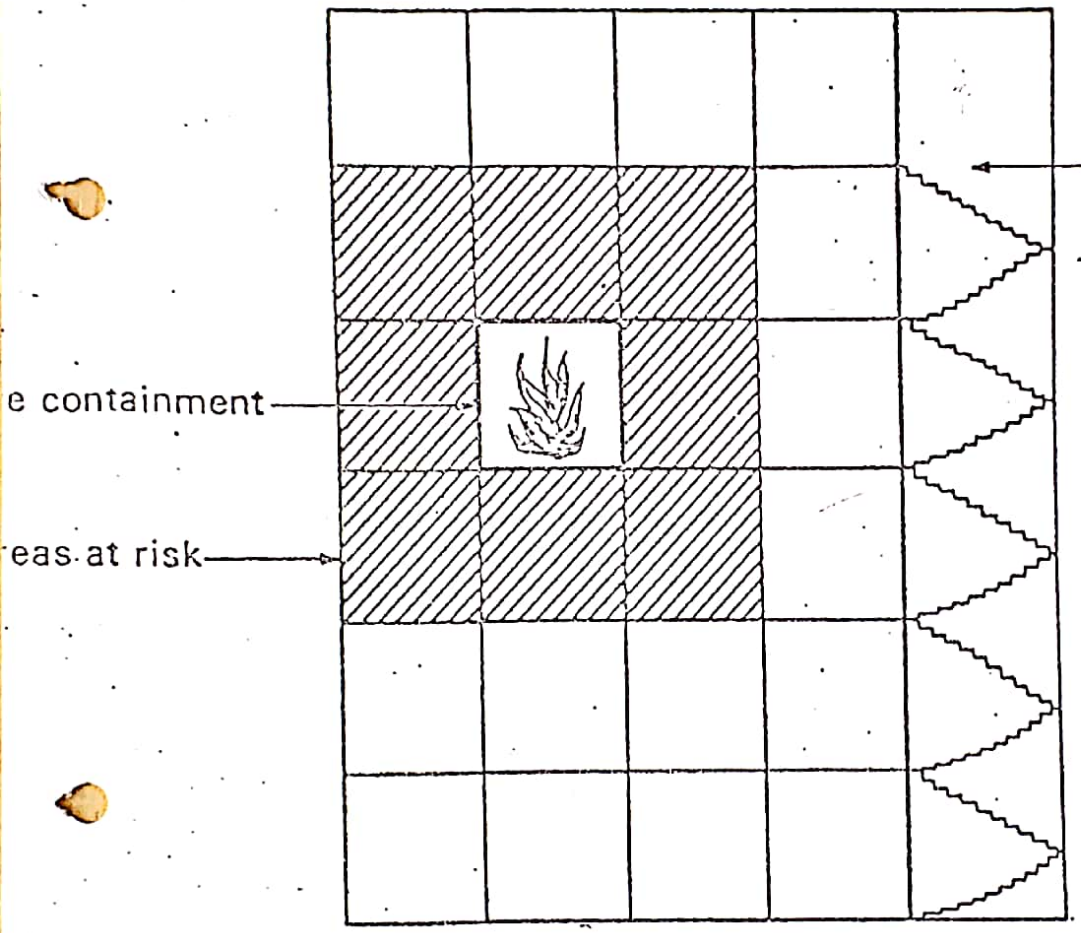


Figure 5.11 Compartmentation

Fire resistance (Figure 5.12)

Once the fire has taken hold it will grow to its full intensity if no measures can be taken to control it. The severity of a fully developed fire depends upon the nature of the fuel and its rate of burning and the factors which influence this, in addition to the fuel, are ventilation to the fire and the thermal resistance of the compartment boundaries. Part of the heat produced by the decomposing fuel is lost through the hot gases leaving the windows, part is absorbed by the walls and the rest raises the temperature level within the compartment. Once the fire has passed its peak, the temperature drops progressively and by the time about 80 per cent of the fuel is consumed the temperature is reduced to 200 -300°C and the fire is dying out.

In a building the fire will reach its peak in one area first and then spread progressively to other areas reaching a peak in each case, but at a faster rate. In some cases a fire may involve a complete building before it is either brought under control or dies down.

If the building is so designed that the structural elements do not fail when the exposure conditions to which they are subjected and separating elements do not allow the fire to penetrate through them, the building is said to have adequate fire resistance. Fire resistance is therefore the ability of building elements to withstand fire exposure and continue to fulfil their designed functions of supporting loads and/or isolating spaces.

In practical terms fire resistance is expressed in terms of time for which the appropriate functions, judged by means of specific criteria, are fulfilled. Conversely, the fire resistance requirement for a building is the time for which these criteria need to be fulfilled. Fire resistance is

usually expressed in units of hours, ranging from a minimum of ½ hour to a maximum of 4 hours. These times are determined for different building components by subjecting them to standard fire resistance tests in specially designed furnaces, in which the 'fire' is represented by a logrithmic temperature rise curve shown in Figure 5.12.2.

These temperatures are maintained close to the exposed surfaces of test constructions. The performance criteria are expressed as

i) stability of loadbearing constructions,

ii) integrity of fire barriers, and

iii) insulation of fire barriers.

Both integrity and insulation establish the success in preventing fire spread through holes and orifices or by excessive transmission of heat.

It needs to be understood that neither the fire resistance requirements specified in the regulations, nor the fire resistance classification obtained in the tests, imply that in an actual building a fire of that duration is expected or a construction will remain intact for exactly that period. These are arbitrary times based on empirical relationships which relate the fire severity in a building to that in the test furnaces. Fire grading of buildings requires such assessments to be made on the basis of their use and these provide the base for each building type. The values are increased for high buildings and for basements of buildings due to difficulties of fire control and the need to ensure the continuing stability of the structure. For single storey buildings, on the other hand, the requirements are reduced because both the evacuation of occupants and the control of fire are not so difficult.

Fire resistance and compartmentation are linked together, the succcess of compartmentation depends upon providing boundaries of adequate fire resistance. In practice,in addition to the design of elements, attention has to be paid to the detailing of junctions between elements and protection of perforations in fire barriers by pipes and ducts of various types.

The method of test for different elements of construction as specified in the standard are used for beams, columns, floors and walls. External walls can be subjected to an internal fire when they are examined in the same way as other fire resistant walls, they can also be subjected to an external fire when they are close to the boundary, in such cases they should be examined for resistance to fire from the external face as well. In the case of doors the retention of integrity and possessing thermal insulation are the two important criteria. Doors in certain buildings, or certain doors in most buildings, are not likely to be subjected to severe fire conditions, their main purpose is to be a barrier to smoke and hot gases. These doors are required to satisfy the integrity and the insulation requirements of the standard for 20 minutes only.

It will be extremely expensive and time consuming to test each and every variation of a construction likely to be used in a building. Furthermore the equipment available in laboratories cannot normally cope with specimens much larger than 4 m in linear dimensions. This requires in practice a system of assessment by which it is possible for the building authority to accept with some degree of confidence the likely performance of a construction which has not been tested.

There are three ways in which this can be done,

i) Assessment made by a competent expert using extrapolation or interpolation techniques of the fire resistance of a construction on the basis of test data from a similar construction.

ii) Calculation of fire resistance, specially of loadbearing structures, on the basis of methods developed by recognized experts or standards bodies.

iii) Use of tabulated data produced by expert associations or similar bodies.

The building authority in consultation with national associations should encourage the development of computational techniques and assessment methods to predict fire resistance of constructions.

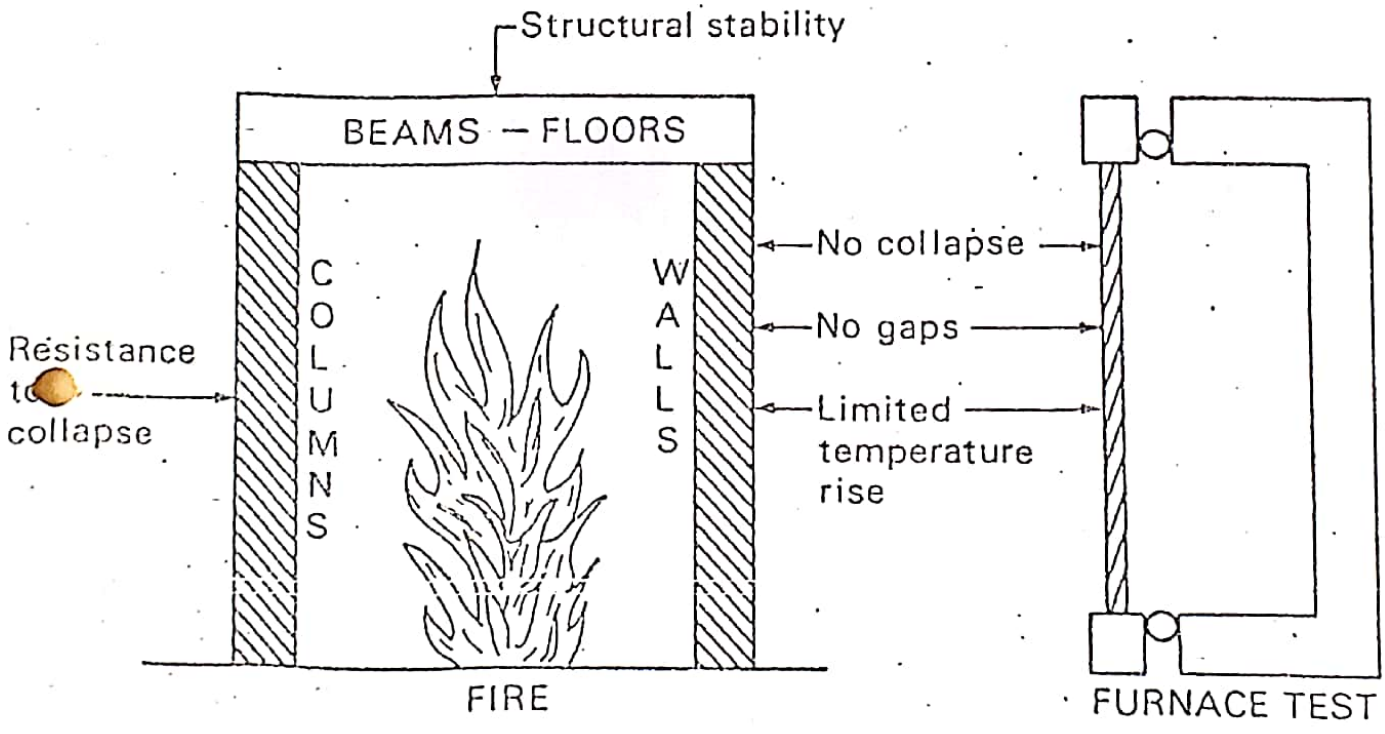


Figure 5.12.1 Fire resistance

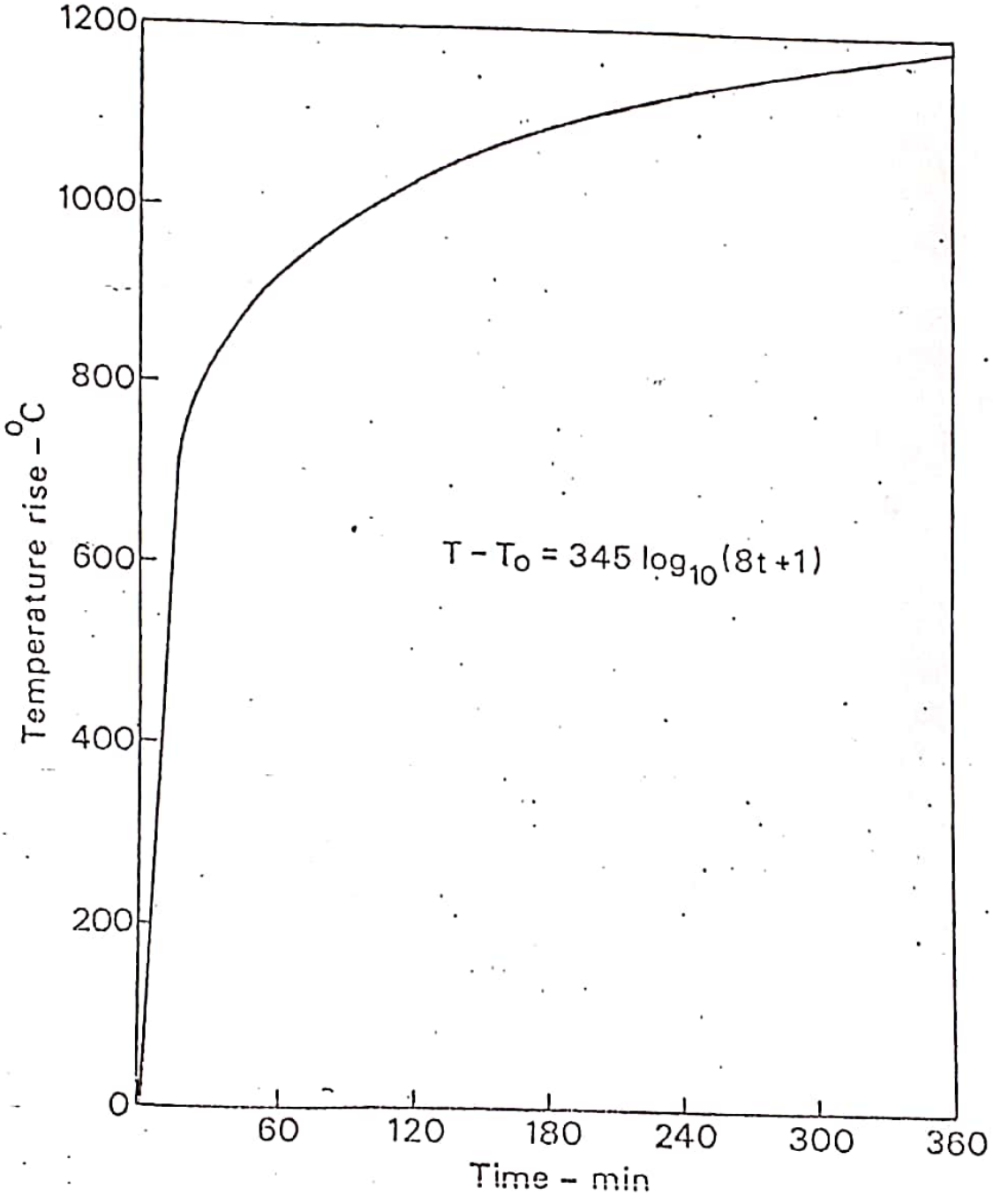


Figure 5.12.2 Time-temperature curve

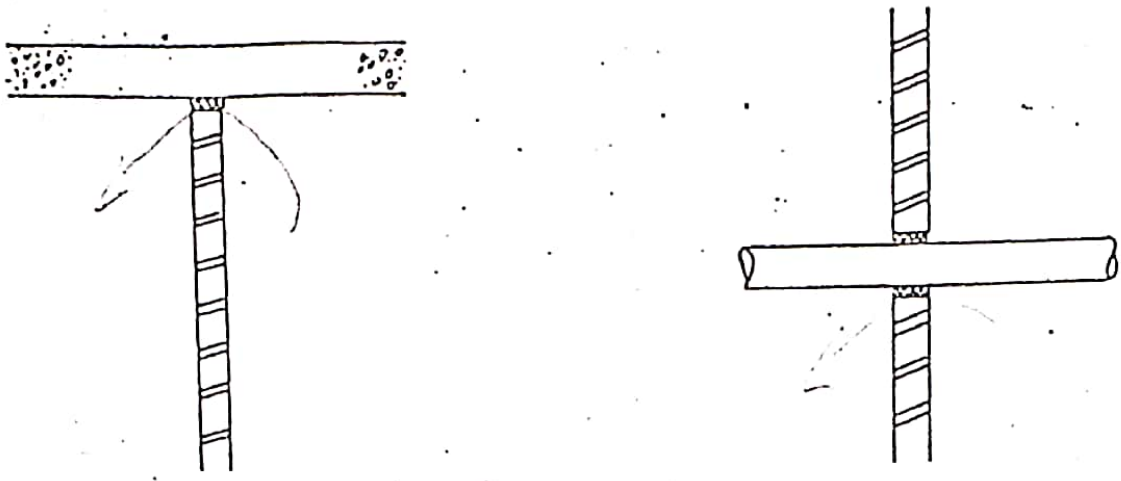
Penetration of fire barriers (figure 5.13)

The passage of services of various types through fire barriers is inevitable in buildings, the more complex the design the greater the number of services. The formation of holes for the services to pass and the nature of some of the materials used for the services can result in the spread of fire through these areas of weakness. It is therefore essential that precautions are taken where such penetrations occur. Two essentials are to seal the opening and to use materials of correct type for the services.

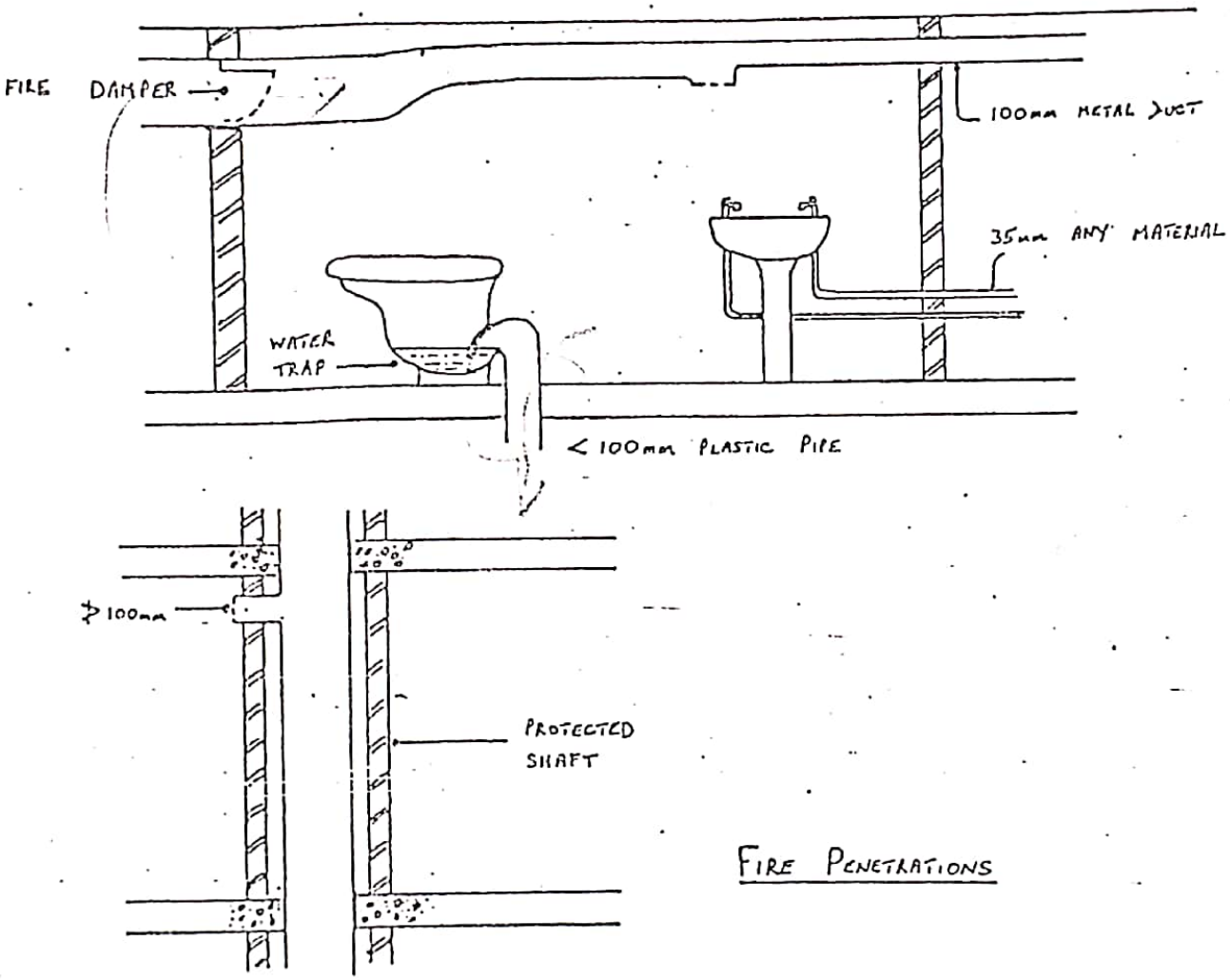
The holes for services should not be much larger than strictly necessary, clearances of more than 15 mm show a lack of proper design. The gaps should be filled by fire seals so that fire cannot exploit this weakness. The sealing should be as good as the fire performance of the construction and if no evidence is available on the performance of the seal, tightly packed noncombustible materials should be accepted.

Metallic pipes or ducts, made of materials which do not soften at temperatures below 800°C, are generally satisfactory in sizes up to 150 mm with the gaps tightly sealed. Where smaller services exist even plastic pipes are acceptable, the size depends on the existence of a water trap. Such a trap prevents the passage of hot gases through a fire damaged pipe as they have to overcome the resistance of the water column to enter other areas.

When dealing with larger size individual pipes or ducts other precautionary measures will be necessary; for example the use of fire dampers where such ducts pass through fire barriers. Where extensive services have to be dealt with, the use of fire resisting shafts to contain the services should be considered. These can pass from floor to floor with only smaller size connections penetrating the walls. Industrial buildings, hospitals and high rise buildings require special consideration to be given to the layout and planning of services through special shafts.



FIRE SEALING



FIRE PENETRATIONS

Figure 5.13 PENETRATION OF FIRE BARRIERS

Cavities and concealed spaces (figure 5.14)

Many fabricated constructions have cavities behind the facing materials and often they traverse the whole length or width of the element. When constructions of this type are put together cavities in one element can communicate with those in the other. If a fire manages to enter the cavities it can spread to other areas and cause damage to other elements by attacking them from within.

Most of the concealed spaces in buildings occur at the ceiling or floor level. Spaces behind a ceiling to a sloping roof or within a joisted floor are examples to be found in many buildings. If a fire enters such areas or ignition takes place in the concealed space, the fire can grow and spread unseen. It can affect areas not directly involved, spread smoke and other undesirable products and create hazardous conditions for the occupants. Frequently the passage of fire through these concealed spaces can by-pass the normal fire barriers, particularly where such barriers terminate at the surface of contiguous elements.

The weakness due to constructional cavities in walls and floors can be eliminated by closing them at the perimeter and where any opening occurs. The concealed spaces should be provided with cavity barriers so that unrestricted spread of fire is not possible.

A cavity barrier may be an extension of a separating element into the concealed space or provided specially to break-up a large area. Cavity barriers are fire resisting constructions, assessed in the same way as any other partition. The degree of protection needed is such that fire cannot spread to the other areas any sooner than it would through the normal barriers. This implies that fire resistance of other elements is added to

that of the cavity barrier to arrive at the total level of protection. It is important to ensure that the same degree of attention is paid to the protection of services going through cavity barriers as has been suggested for fire resisting separating elements.

It is not necessary to construct cavity barriers from non-combustible materials provided the correct level of protection is obtained.

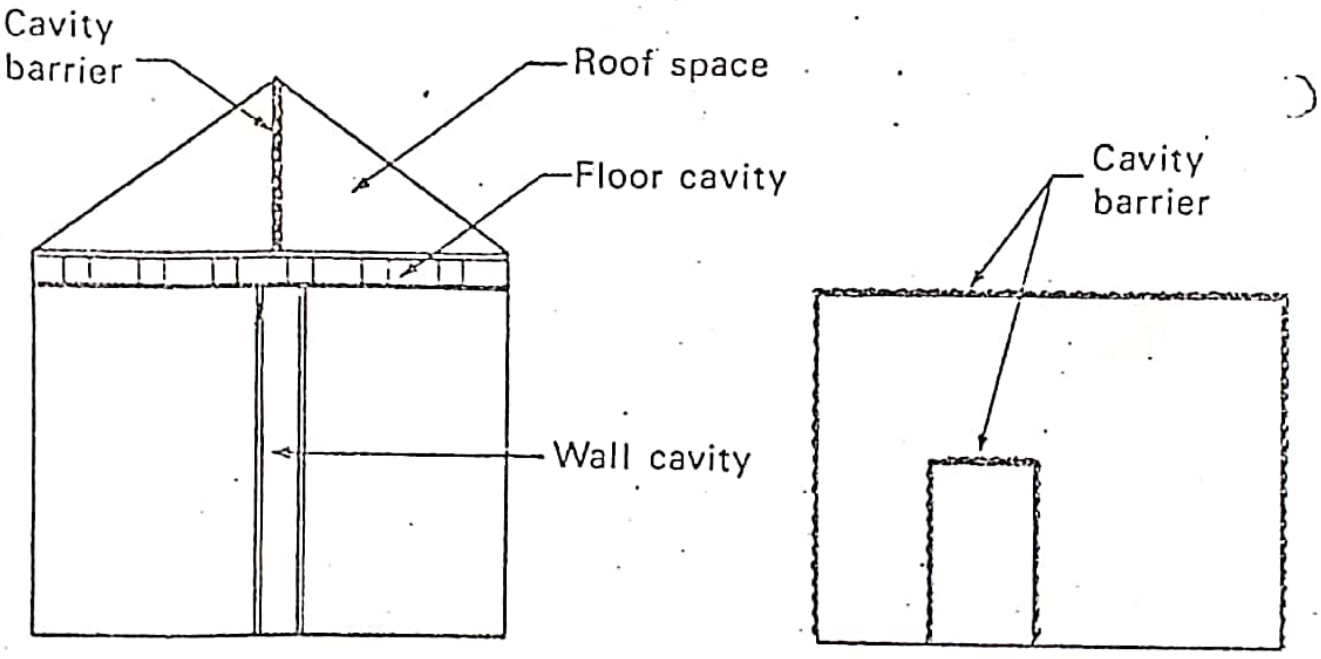


Figure 5.14 Cavities and concealed spaces

Lifts (figure 5.15)

Lift shafts provide a vertical means of communication between different floors of a multi-storey building and if the lift landing doors are not of a suitable design smoke can enter the shaft and be transferred to higher floors. If the fire spreads to the lift lobby, its vertical spread is also possible by the same route. If the lifts are not installed in a lift lobby which is part of a fire resisting compartment then lift landing doors on all floors must be of fire resisting type.

It is also important that occupants are advised not to use lifts to escape from a fire floor as in case of malfunction they could be trapped. The touch type of call buttons can also react to the hot gases and bring a lift to the fire floor. In high rise buildings it is important to have an automatic system which brings lifts down to the ground floor on receiving a signal and keeps them immobilized. Only by special switching arrangement can the lifts be used.

The work of the fire brigade is facilitated if they have the use of a lift in large multi-storey buildings. The regulation proposes in certain buildings the allocation of one or more of the lifts as a fire-fighting lift operated by manual control. Such a facility will enable the fire-fighters to get quickly to the seat of the fire and attack it more effectively.

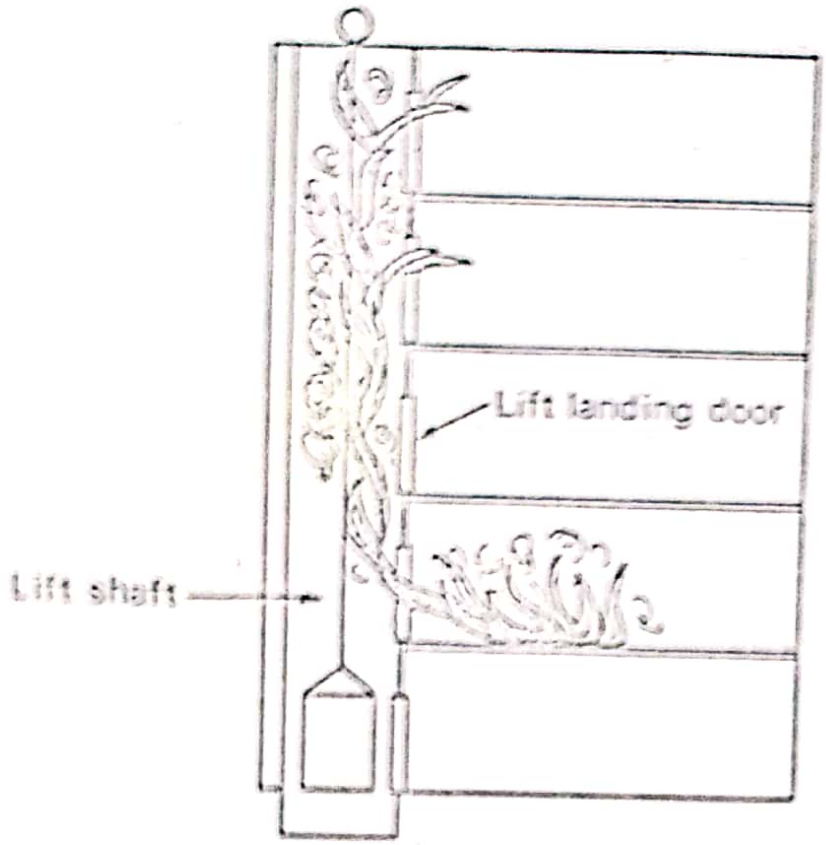


Figure 5.15 Lifts

Manual fire fighting equipment (figure 5.16)

Control and extinguishment of fire is normally considered to be the responsibility of the fire brigade. The ability of the fire brigade to successfully extinguish a fire depends, amongst other things, on the size of the fire on their arrival. Most fires start from a small source and if tackled immediately could be suppressed with little difficulty. Manual fire-fighting equipment is usually provided to enable an immediate attack on fire by the person who detects the fire or in industrial and commercial buildings by a trained member of the staff. Untrained people cannot be relied upon to achieve a high success rate in dealing with even small incidents.

Two types of manual fire fighting equipment are usually provided, portable fire extinguishers and hydraulic hosereels. Portable fire extinguishers are of five main types, distinguished by the type of extinguishing medium, water, foam, dry powder, carbon dioxide and halon.

Their main applicability is as below:

Water - most solid fires except electrical apparatus

Foam - liquid fires except electrical apparatus

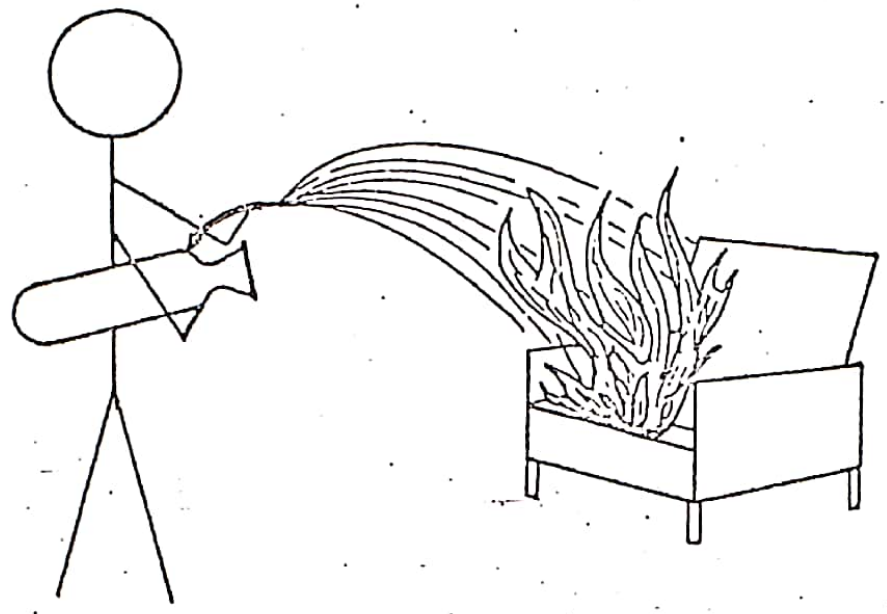
Dry powder - most fires

Carbon dioxide - most fires

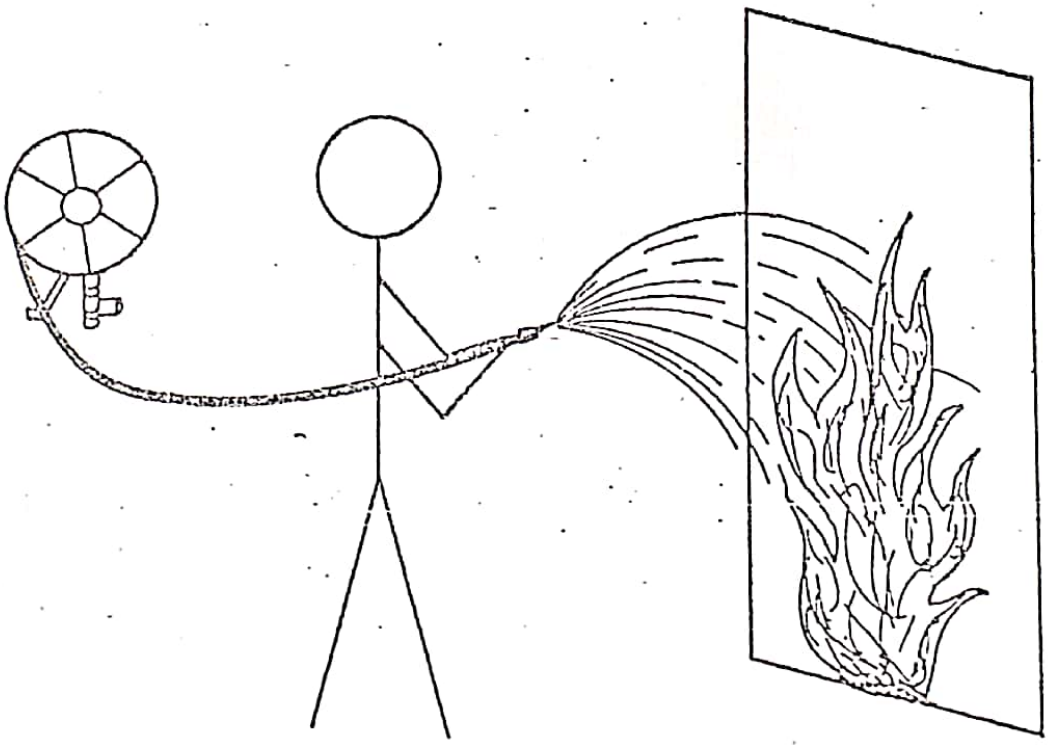
Halon - most fires

The contents of most portable extinguishers are usually exhausted in around 1 minute and it is doubtful if an untrained user can control the fire in this time. Hence their specification in buildings without trained staff is not recommended.

Hosereels on the other hand have an unlimited supply of the extinguishing medium, water, and could be relied upon to make some contribution to fire control. They need to be sited where they are easy to locate and operate and the discharge should preferably have a simple control to change from a jet to a spray delivery. Hosereels are also of use to the fire brigade personnel if they are dealing with a small fire. Statistics show that the majority of fires can be extinguished by the use of hosereels provided they have been attacked without delay. It is important to ensure that the occupants' first response should be to inform the fire brigade or other emergency authorities of the occurrence of a fire and only then attempt to attack it.



Extinguisher



Hosereel

Figure 5.16 Manual fire fighting equipment

Fire extinguishing systems (figure 5.17)

In certain buildings because of the use or the size it is desirable and sometimes necessary, to install an active system for fire control. The most common system of this type is a sprinkler installation where sprinkler heads provide cover to the whole floor of a building and operate when hot gases from the fire cause a fusible link to come apart or a glass bulb to break. This causes a spray of water to be delivered to the burning contents underneath and provided the sprinkler is matched to the risk, the fire should go out or be prevented from increasing in size. The systems are usually designed so that a number of sprinklers, usually about 8 to 10, can operate simultaneously. Operation of a larger number will require an unduly large water supply system to be provided.

It is important to ensure that the sprinkler installation is carried out in accordance with acceptable standards, two well known guides are the Rules of the Fire Offices' Committee (29th edition) from the UK and the National Fire Protection Association from the USA. A British Standard based on the FOC Rules is also available and recommendations are being prepared by the European Insurance Association (CEA).

Sprinkler installations are designed primarily to control property loss by controlling the size of the fire and in the first instance their application is influenced by concessions given in insurance premiums. However because of their influence on fire growth the regulations have recommended that concessions be given on compartmentation sizes when sprinkler installations are (voluntarily) provided. To reduce the fire hazard in certain high risk areas and in high rise buildings, it is also recommended that their provision should be made compulsory.

High rack storage buildings present special problems of fire spread in concealed spaces and the difficulty of controlling such fires by the normal fire brigade appliances. The use of special sprinkler systems is particularly beneficial in such occupancies.

Other fixed fire extinguishing systems are carbon dioxide, halon and foam installations. Each of these has a special application and are provided by the owner to deal with some special risk such as computer installations, fuel tanks etc. No account can be taken of these in considering the relaxation of fire protection measures.

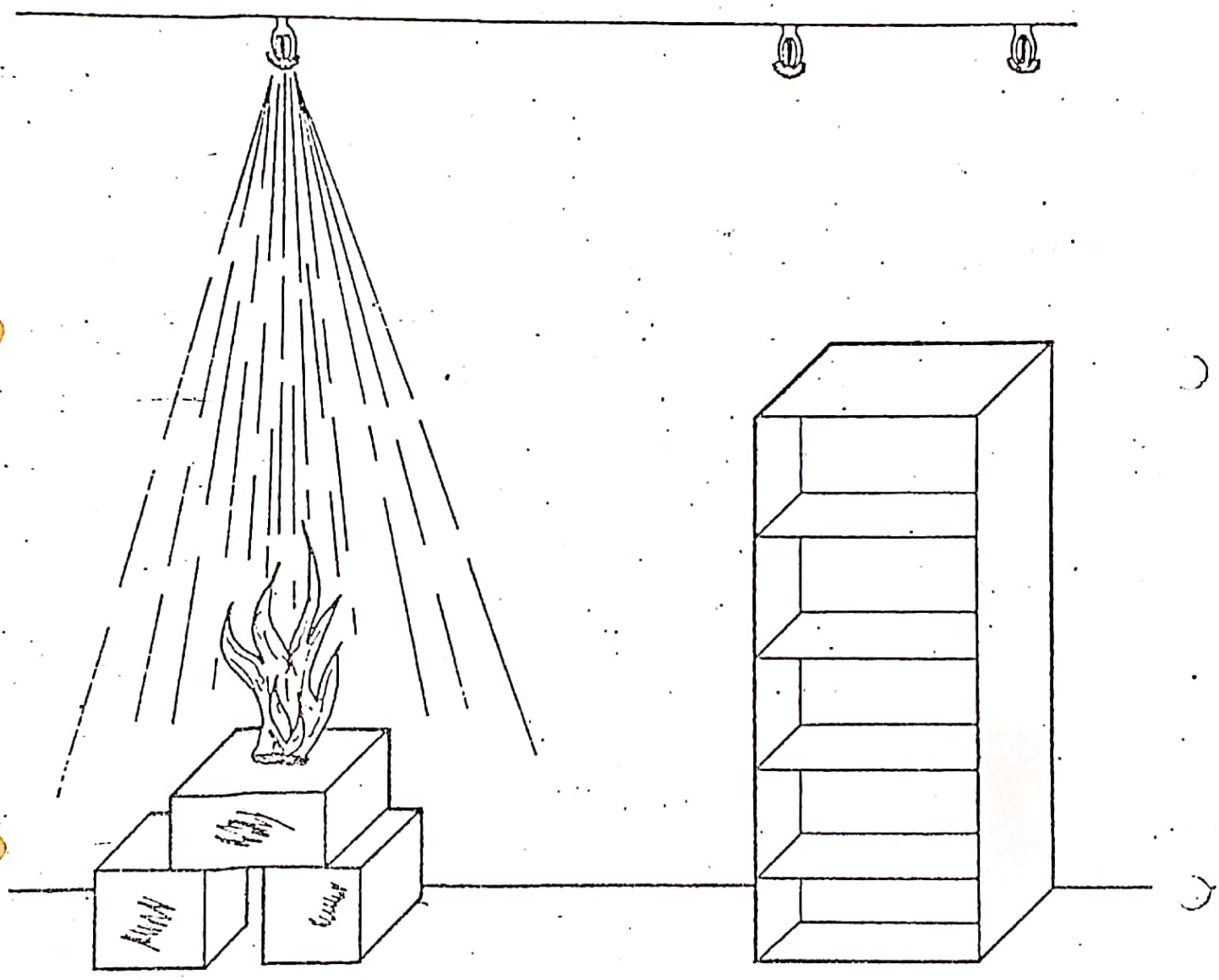


Figure 5.17 Fire extinguishing systems

Water supplies for fire fighting (figure 5.18)

Fire brigades can only bring small quantities of water with them to a fire site to deal with a fire incident. It is therefore essential that provision is made for the availability of water within a reasonable distance of each building. The provision of hydrants in a road or street is not the purpose of these regulations but attention has been drawn to this need. However, with certain types of buildings, shopping complexes, high rise buildings and special risk buildings, it is essential that suitable hydrants are provided at ground level outside or just inside the building to which the fire brigades can connect their hoses. In high rise buildings rising mains must exist over the whole height of the building with suitable outlets at each floor. It is also necessary to ensure that sufficient water pressure is available and it may be necessary with high buildings to have booster pumps and/or water tanks installed on top of the building. All fittings must be to the satisfaction of the fire brigade.

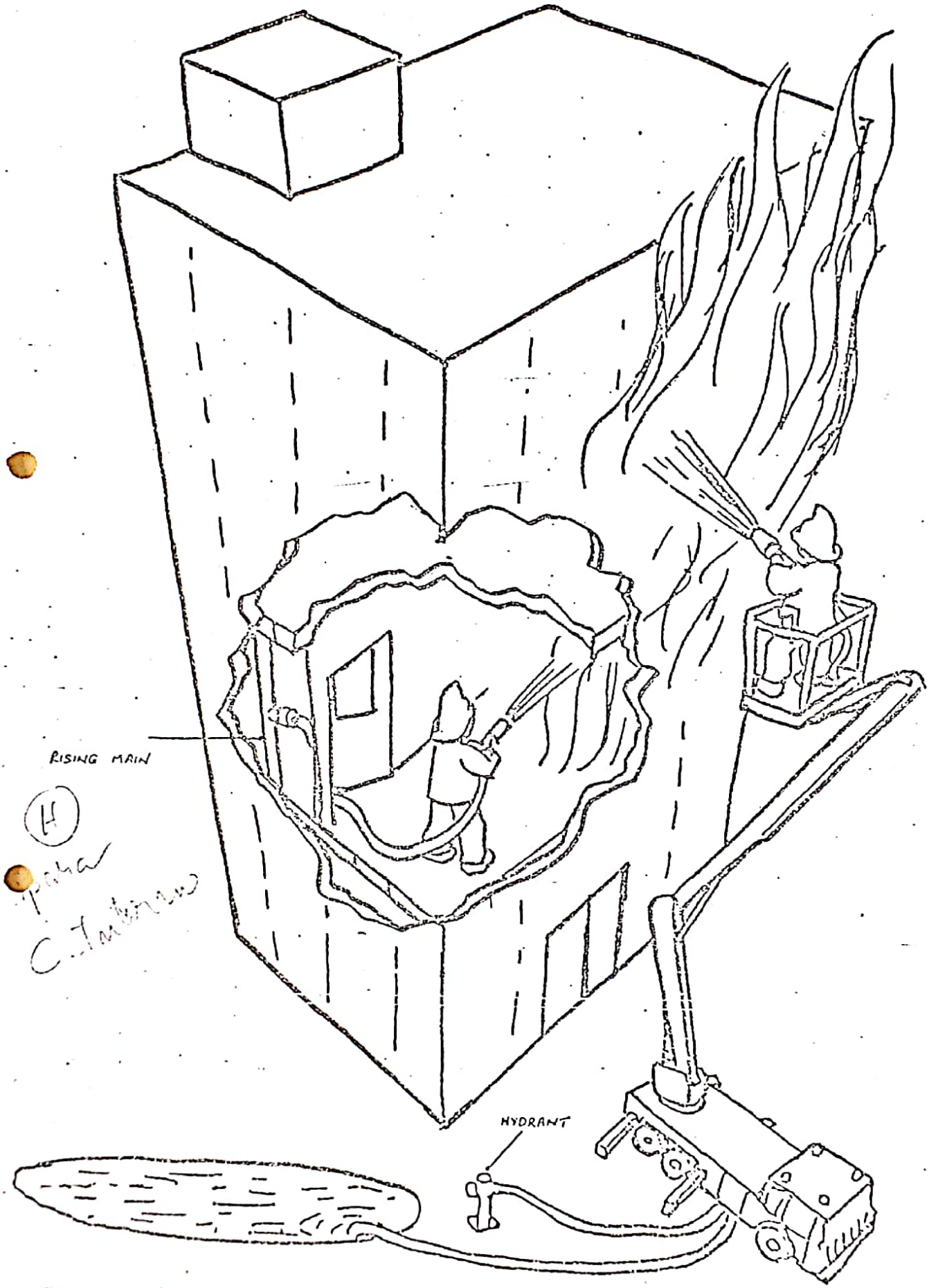


Figure 5.1 Water supplies for fire fighting

CB

Fire brigade access (figure 5.19)

Fire brigades need to get as close to a building as possible so that they can attack the fire without delay and do not have to provide longer hoses than necessary. Even for small buildings such as houses, the fire brigade should have suitable approach roads capable of accommodating their appliances. With large buildings special facilities with hardstanding to take the weight of the heaviest appliance should be part of the building design. With tall buildings the use of turntable ladders and other equipment must be considered hence any projections which will prevent getting close to the facade of the building should be avoided.

With high rise buildings, fires cannot be always fought from the outside, therefore fire brigades need facilities to be able to enter the building to travel up to the floor on fire. This requires the use of one or more protected stairways and the use of at least one lift which should be provided with facilities for manual control and a reliable electric supply. The design features for lifts, stairways, lobbies and doors should take into account the need for the fire brigade to move cumbersome equipment through these areas.

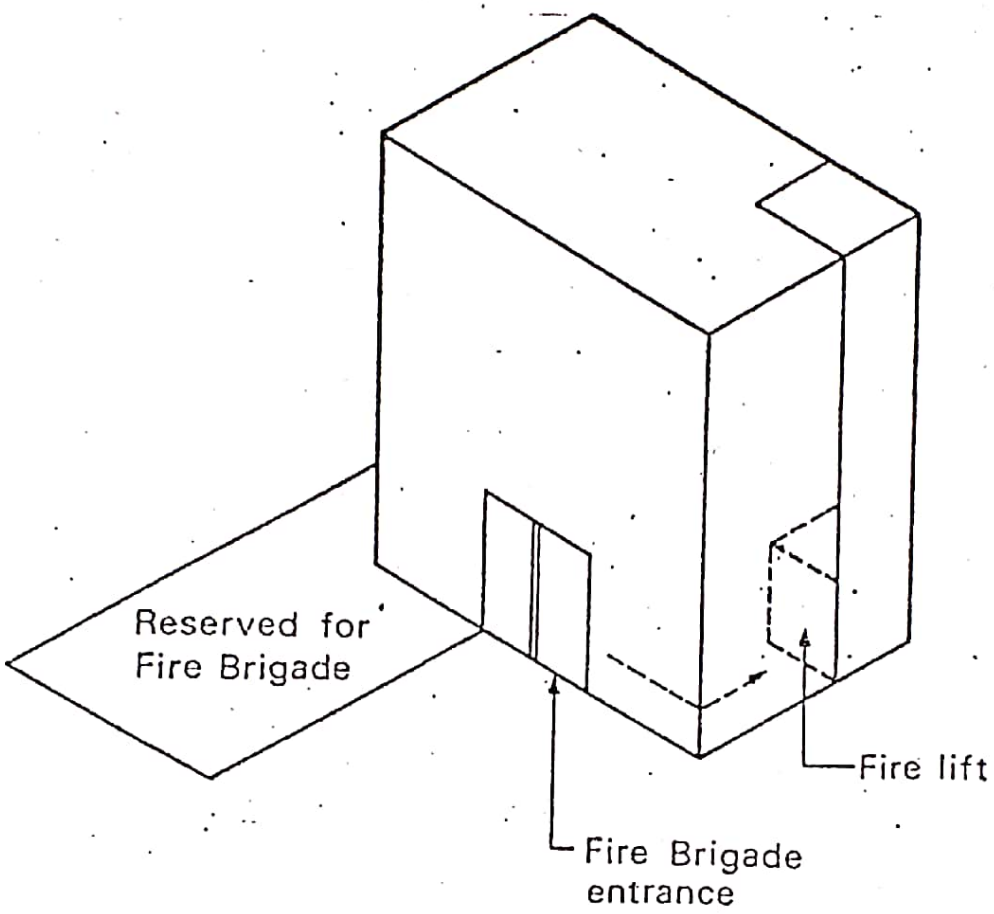


Figure 5.19 Fire Brigade access

Site and building plan (figure 5.20)

It is necessary to avoid the wastage of any time when the fire brigade arrives on the scene of the fire. With most buildings the fire brigade will know the outside facilities. It is therefore important to have all the available facilities inside a building listed and shown on one or more plans for the use of the fire brigade. It will be useful for the management of large buildings to discuss these with the fire brigade and have them available for any regular inspection of the building facilities. The plans shall be readily available, easy to understand and show on them the external facilities as well. In certain buildings, such as hotels, plans should be displayed for the use of the occupants to make them aware of the facilities provided for their safety.

CHAPTER 6

ESCAPE ROUTE DESIGN

General

This chapter deals with decisions on the number and the nature of escape routes, their position and protection, exits from rooms, storeys and floors, as well as other aspects to ensure that the occupants will have no serious problems in moving directly, or in stages, from the fire zone to complete safety outside the building. Only domestic buildings of 1 and 2 storeys in height are excluded as the normal movement facilities are considered to be adequate for the escape of occupants.

To keep the design concepts simple, any variations from the norm is given in chapters 8 and 9. With escape route design the main requirements do not lend themselves to a performance specification. It will be difficult therefore to show whether an alternative system will provide the same level of protection for the occupants. However, alternatives should not be ruled out and the designer should provide the relevant data to the building authority for their consideration.

Number of exits and escape routes

The general requirement is that at least two exits or escape routes should be provided from every building, so ensuring that any person confronted by a fire can turn away from it and make a safe escape. Additional exits and escape routes may be necessary to meet requirements for travel distance. However, except where otherwise prohibited in chapter 8, buildings not exceeding four storeys in height, which also meet the requirements for maximum travel distance in one direction, are permitted to be served by a single stairway (fig 6.1).

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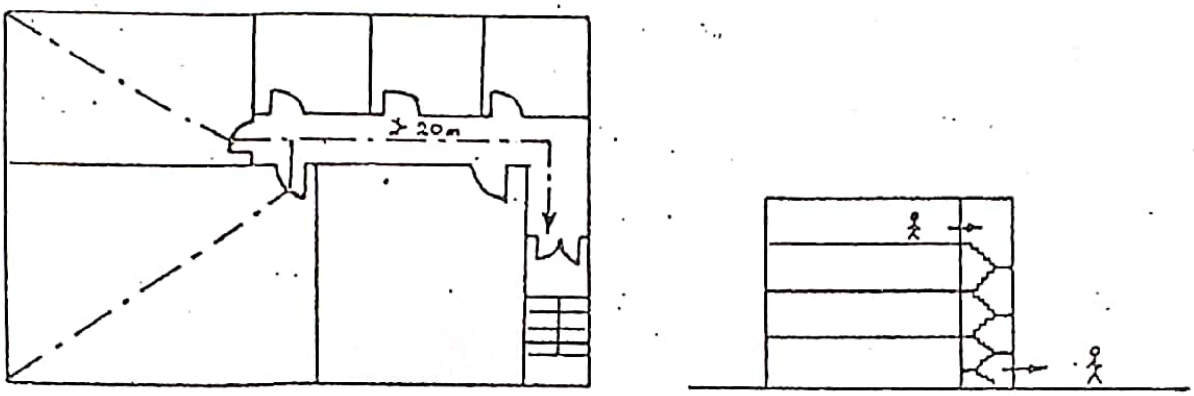


Figure 6.1 Escada única

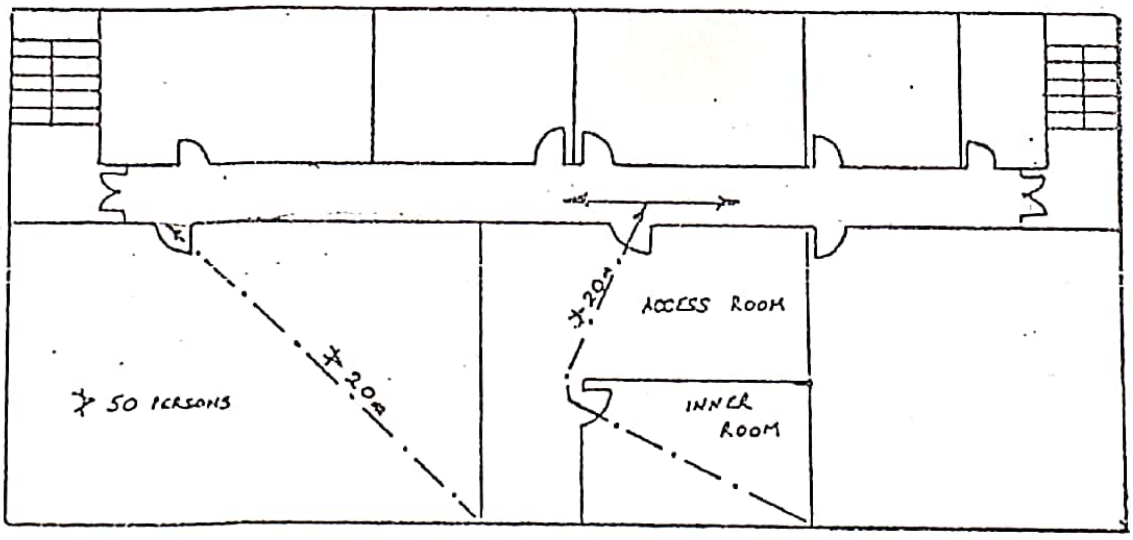


Figure 6.2 Dependências com saída única

Distances of travel

The distance occupants need to travel to reach a place of safety should be limited to that which a normal person can cover in a few minutes with the escape routes retaining a level of visibility at which movement is not impeded. The greatest restriction on travel distance is placed where the occupants have no choice but to make their way along a single escape route (eg. a dead end - fig 6.3). Where escape is possible in more than one direction, the permissible travel distances are increased.

In regulation 6.2, the basic requirement is that where escape is possible in more than one direction the travel distance from any point on a storey to the nearest storey exit (that is a door giving direct access to a protected stairway or an associated lobby, an external stairway, or a final exit from the building) should not exceed 40 m. Where escape is possible in one direction only, the travel distance should not exceed 20 m to the storey exit (where only one storey exit is permitted) or to a point from which escape is then possible to alternative exits, in which case the overall distance should not exceed 40 m (fig 6.4). These distances have been reduced to 30 m and 15 m for high fire load storage buildings, and to 20 m and 10 m for high fire risk industrial buildings. Restrictions are also given in chapter 8 in the case of Old Peoples Homes, Schools for handicapped children and Hostels for handicapped children. In the case of low fire risk industrial buildings, concessions are made so as to permit travel distances of 60 m and 30 m. Other concessions are given in chapter 8, eg. ground storey car parks and single shop units.

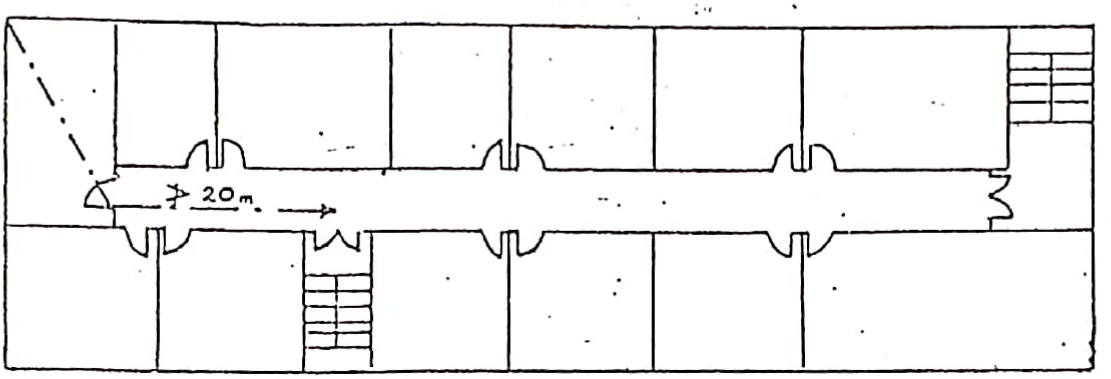


Figure 6.3 Distâncias de caminhamento

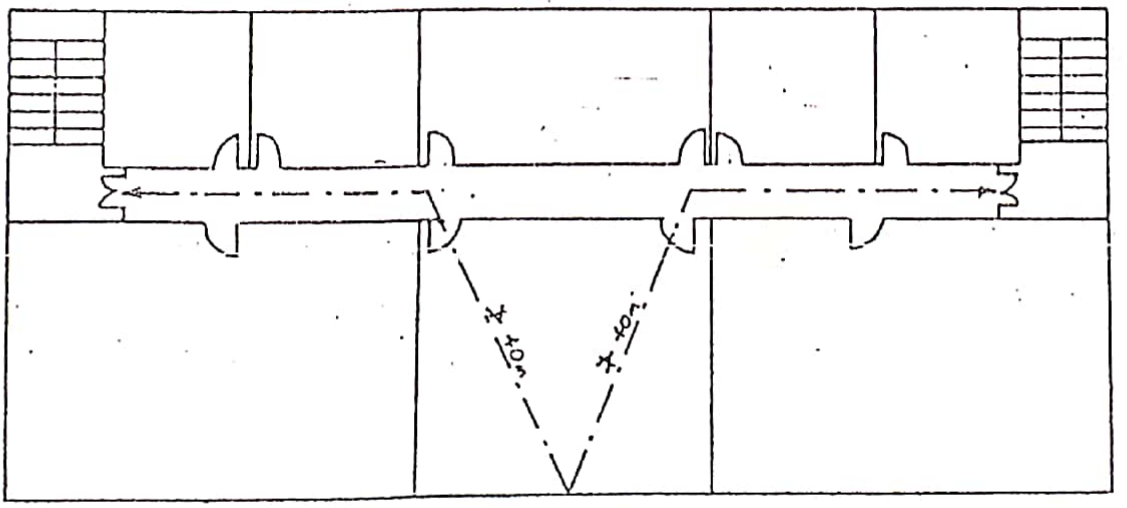


Figure 6.4 Distâncias de caminhamento

Width of exits and escape routes

The number of people expected to use the exits and escape routes is based on the expected occupancy level for which data is provided in the table 6.2 of the regulations. In some occupancies fixed seating or other accommodation is provided from which the occupancy level can be determined; in other cases the data given in table 6.2 may be used and for each room or storey an estimate is made. Some of the occupancies have a more reliable and consistent loading levels, eg. offices and factories, but in others the occupancy levels may vary during parts of the day and during different parts of the year. Shops and stores will have more occupants at weekends and during special events (eg. before Christmas and during 'Sales').

The width of exits and escape routes should enable the occupants to vacate a storey in not more than 2.5 minutes. The values given in tables 6.3 and 6.5 of the regulations assume total evacuation at a rate of discharge of 40 persons per minute per 500 mm of exit width, with an allowance for exits used by less than 220 persons and for the standing capacity of stairways. Extrapolation is permitted where greater numbers of people are involved, but in general constraints on travel distance will necessitate additional exits anyway.

In the case of flats and maisonettes, because of the high degree of compartmentation required for these premises it is considered that a single minimum width of 1000 mm will be adequate as it is not expected that all the occupants need to evacuate simultaneously. The width of exits and escape routes for assembly buildings in view of their complexity is given in chapter 8.

Except in the case of buildings (or parts of buildings) permitted to be served by a single exit or escape route, one of the exits should be assumed obstructed by fire. The requirements specified in respect of flats and maisonettes, and assembly buildings, have taken this into account. Elsewhere, in using tables 6.3 and 6.5, in a building (or part) served by two exits/escape routes both should be capable of evacuating all the occupants. Where three or more exits are provided, each in turn should be discounted in assessing the aggregate widths of the others.

Siting of exits and escape stairways

Exits and escape stairways should be of a sufficient number and so located that the permitted travel distances are not exceeded. Except where a single exit or escape stairway is permitted, all exits and stairways should be remote from each other: thus enabling the occupants to turn away from any fire (other than in permitted dead-end situations). The provision of two exits will not afford effective alternative routes of escape if they are situated close together and could become inaccessible at the same time from one fire. Except where two routes are adequately separated from each other, they are affording escape in one direction only unless they diverge at an angle of more than 45° (fig 6.5). The siting of escape stairways should also be such that no person should have to enter the enclosure of one stairway to reach another (fig 6.6). Because of the ease at which smoke can quickly travel throughout all floors comprising open spatial planning, the routes of escape should be planned away from the open connections between the floors (fig 6.7). Equally, any permitted accommodation stairway or escalator would present a similar risk (fig 6.8)

Where buildings are served by stairways located in a central core, in order to minimise the chances of a fire prejudicing access to both stairways any connection across the core (eg. a lift lobby) should be enclosed at both ends with fire doors (fig 6.9) and any corridor provided between the core and the accommodation should be sub-divided on both sides of the core.

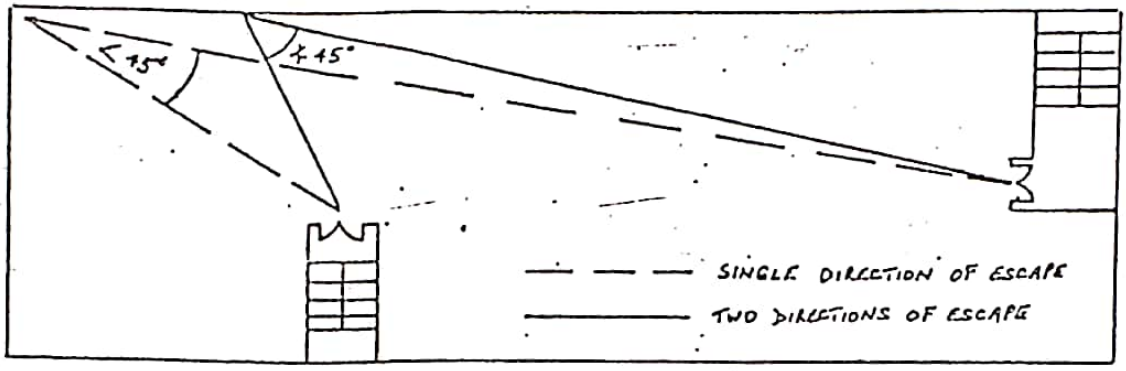


Figure 6.5 Siting of exits

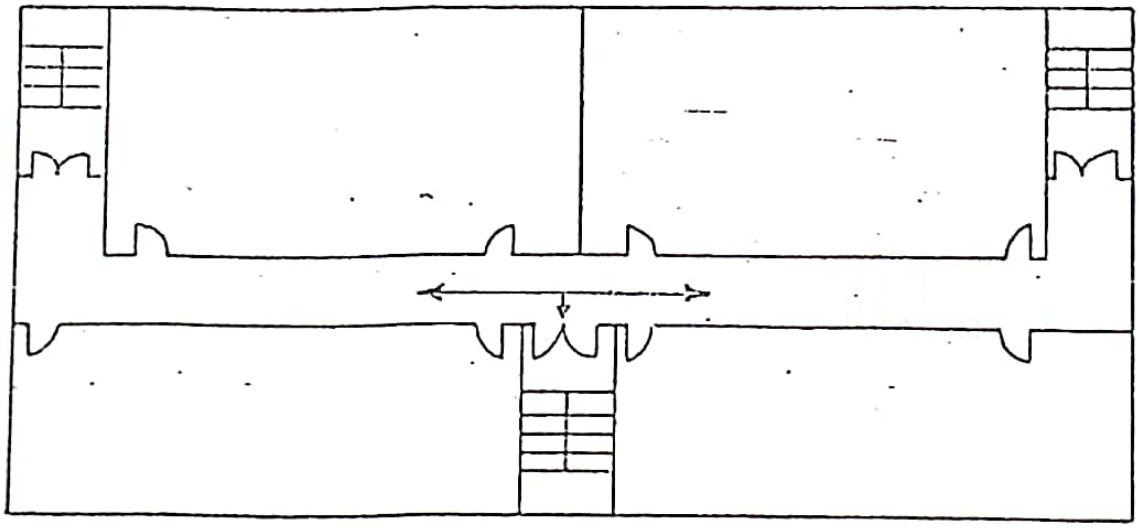


Figure 6.6 Siting of stairways

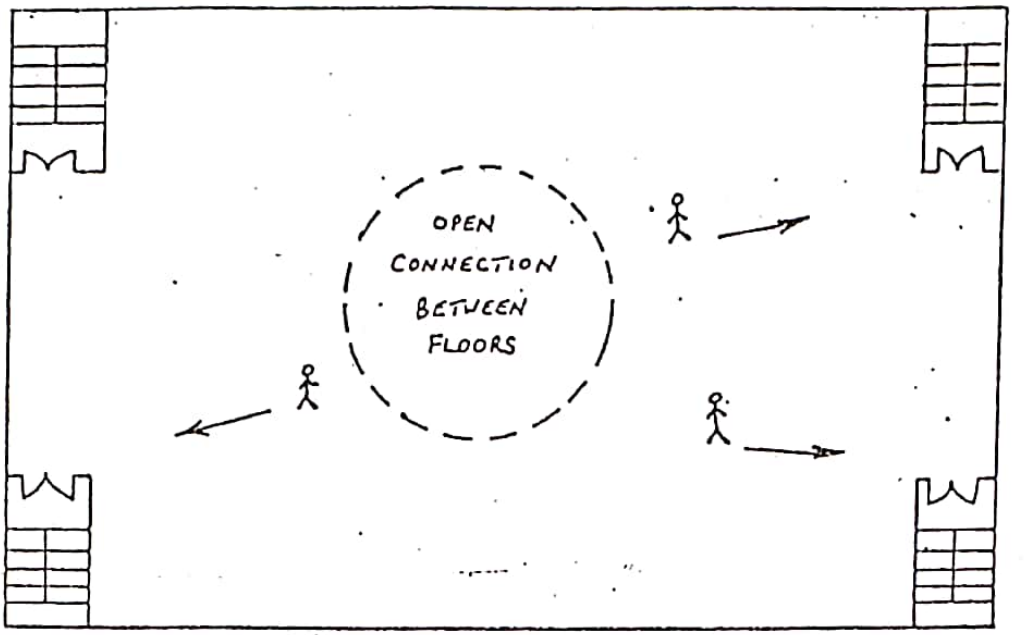


Figure 6.7 Siting of stairways (open spatial planning)

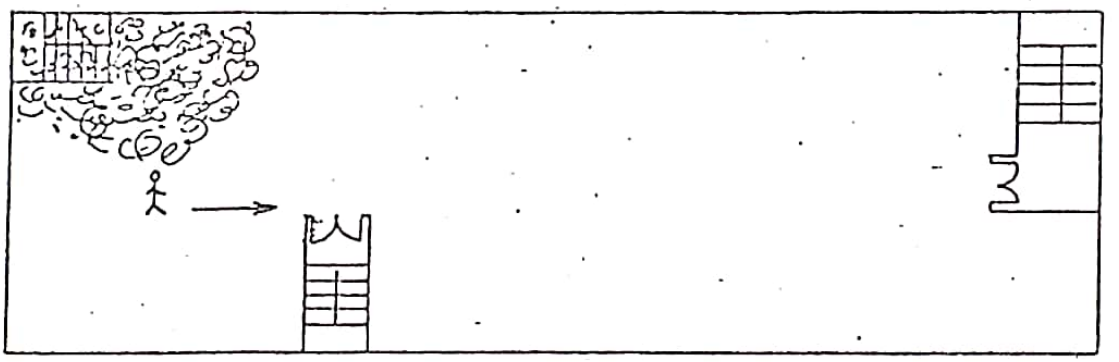
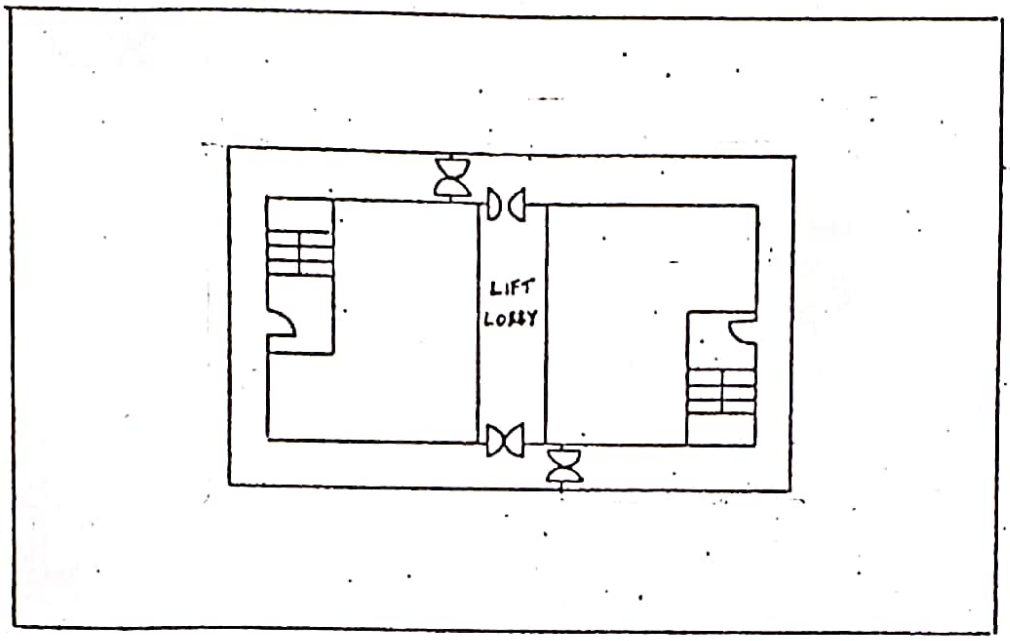


Figure 6.8 Accommodation stairways



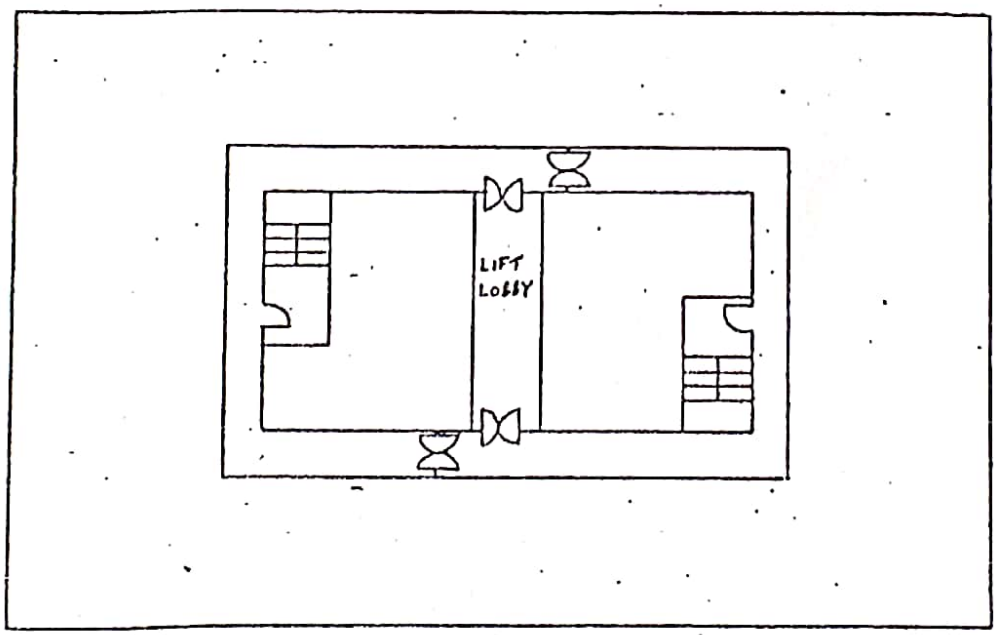


Figure 6.9 Alternative central core layouts

Discharge from escape stairways and final exits

The safest discharge arrangement is for the stairway or final exit to deliver directly to the street at ground level. However, subject to limitations, access may be permitted into a courtyard or arcade (figure 6.10) from which safe escape can be made. In designing the escape routes, consideration should also be given to possible dangers from passing road traffic.

Except where a stairway delivers only to its final exit, consideration needs to be given to the necessity of providing appropriate emergency and direction signs to indicate the way out (eg. where a stair also connects with the basement storey(s).

Design and construction of escape stairways

In general, all escape stairways should be constructed of non-combustible materials. However, this requirement is relaxed in the case of single family dwelling houses, the private stairway within any maisonette and common stairways above ground level in blocks of flats or maisonettes not exceeding three storeys in height. Except in the case of stairways used also as fire fighting stairways, combustible materials may be used as a finish to any tread or landing.

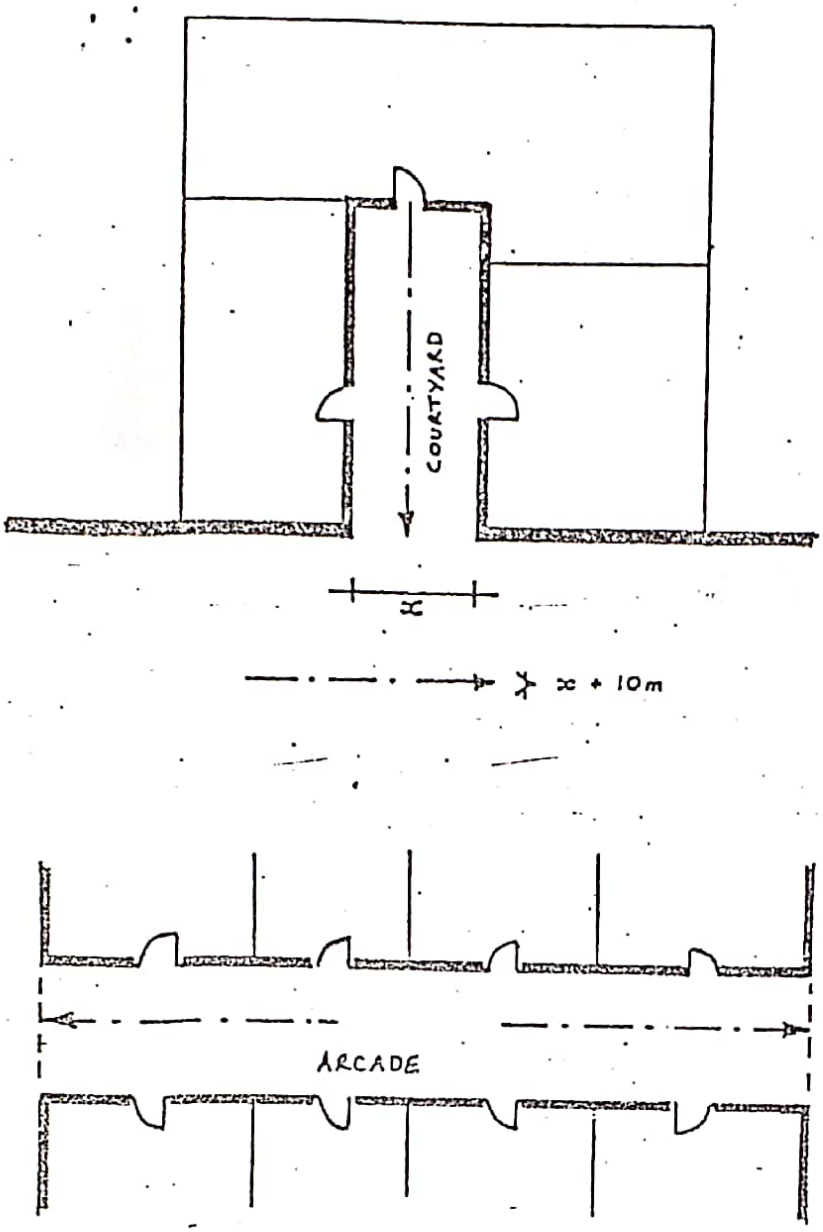


Figure 6.10 Discharge from escape stairways and final exits

Protection of escape stairways

All internal escape stairways should be enclosed with fire resisting construction to prevent smoke and heat entering the stairway and rendering it impossible for escape purposes; and to prevent fire spreading by way of the stairway from one storey to another. However, such protection is not considered necessary in the case of single family dwelling houses of two storeys in height and for certain small office and shop premises covered in chapter 8.

To prevent fire spreading externally into a protected stairway, limitations are placed on the distance between the windows to a stairway and any adjoining windows (fig 6.11) and on the nature of the construction between any such openings. Similarly, any permitted external stairways should be protected against fire and smoke issuing from the building.

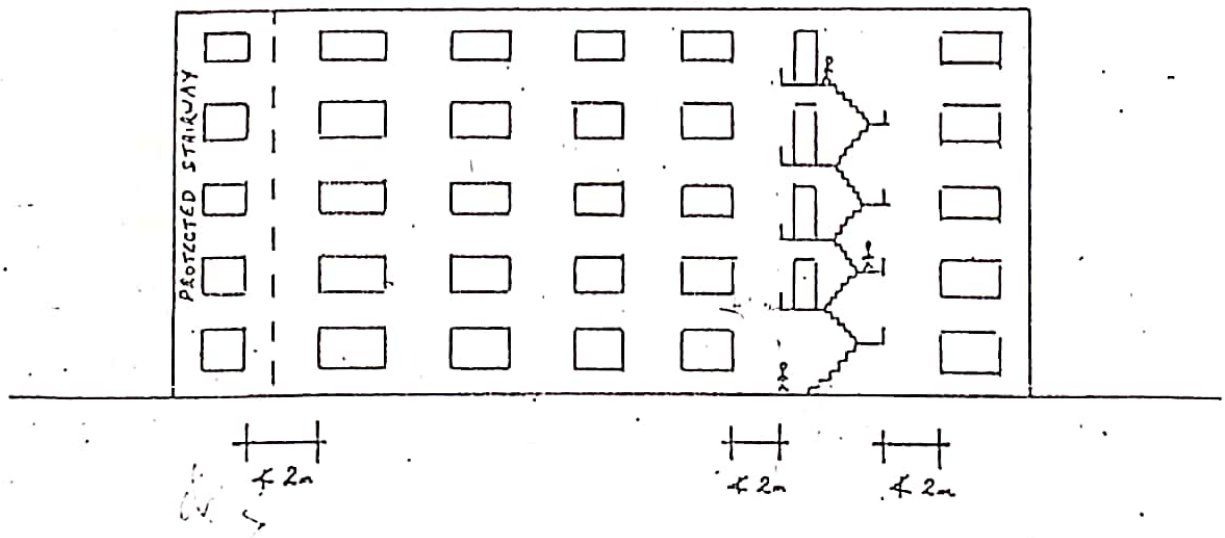


Figure 6.11 Protection of escape stairways

Protected stairways

In buildings served by two or more stairways, in order that such stairways remain effective alternative routes of escape it is essential that no direct links exist between the enclosures separating different stairways and their respective final exits. This also applies to any building comprising different types of occupation requiring separate and independent escape stairways (fig 6.12). In order to minimise the risk of fire entering a stairway, access to the stairway at each storey level should be restricted to a single doorway (fig 6.13). Similarly, it is important to ensure that no fire risk exists within a protected stairway. Thus limitations are placed on the type of accommodation (if any) permitted to be entered from within a stairway: particularly in the case of buildings, or parts, served by a single stairway and in the case of fire-fighting stairways. However, no such restrictions are placed on protected stairways serving single family dwelling houses and within any maisonette.

Protected lobbies

To afford greater protection against the ingress of fire and smoke into a protected stairway, particularly in the case of a building (or part) permitted to be served by a single escape stairway (other than a single family dwelling house or within a maisonette), stairways connecting with car parks and with areas of high fire risk, or in connection with basements and with high rise buildings, access to such stairways should only be by way of a protected lobby (or protected corridor), which in some cases should be provided with natural ventilation (see section on smoke control). In the case of single stairway buildings, a lobby at the head of the stairway is not required (fig 6.14).

Limitations are placed on the minimum distance between doors to protected lobbies (fig 6.15)

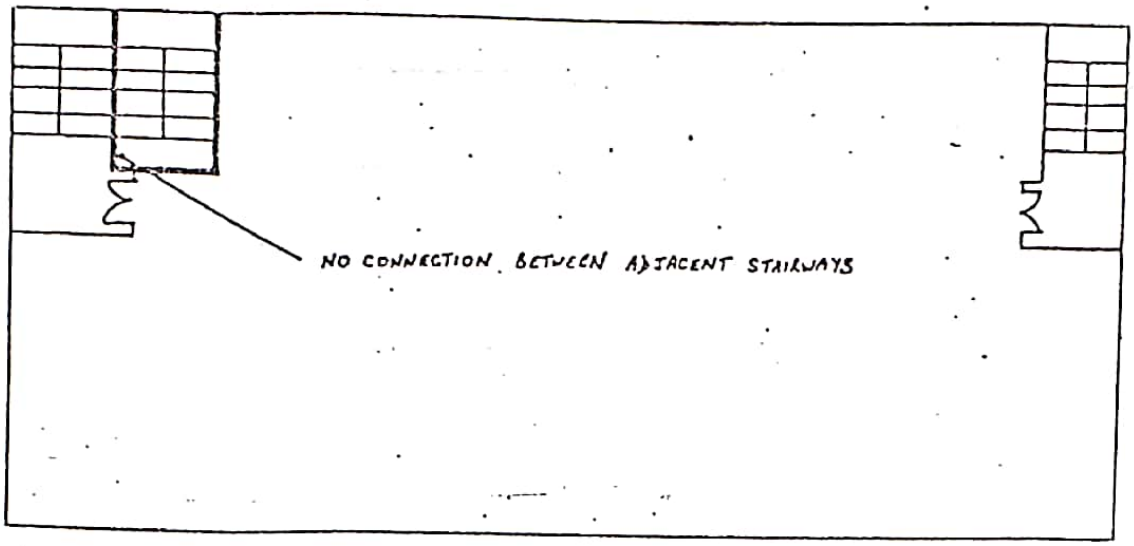


Figure 6.12 Protected stairways

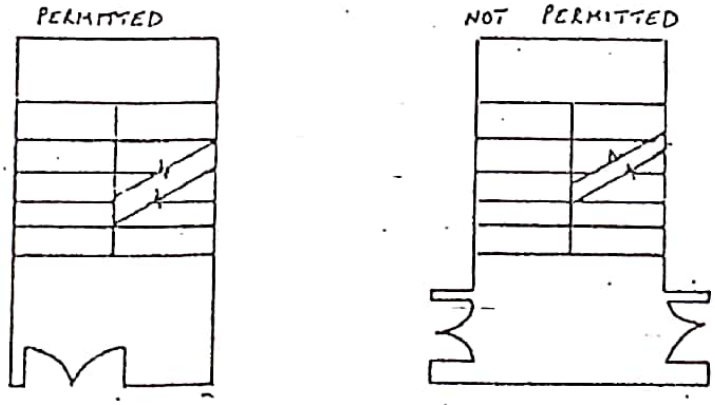


Figure 6.13 Storey exits

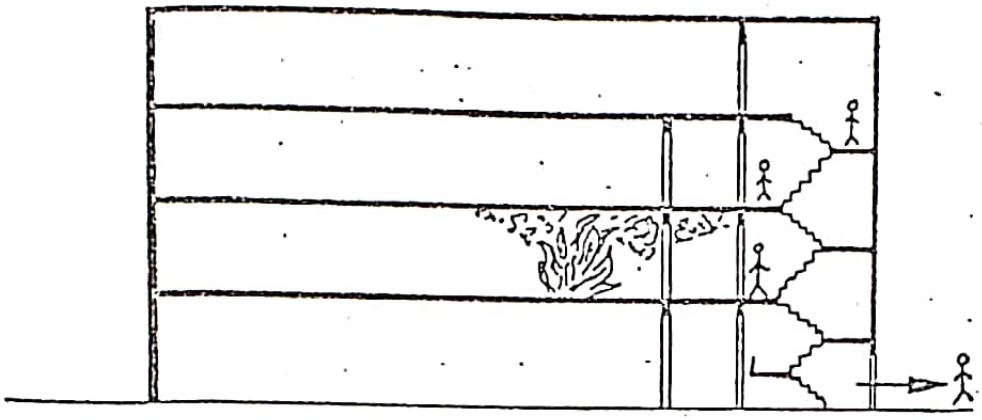


Figure 6.14 Protected lobbies (single stair building)

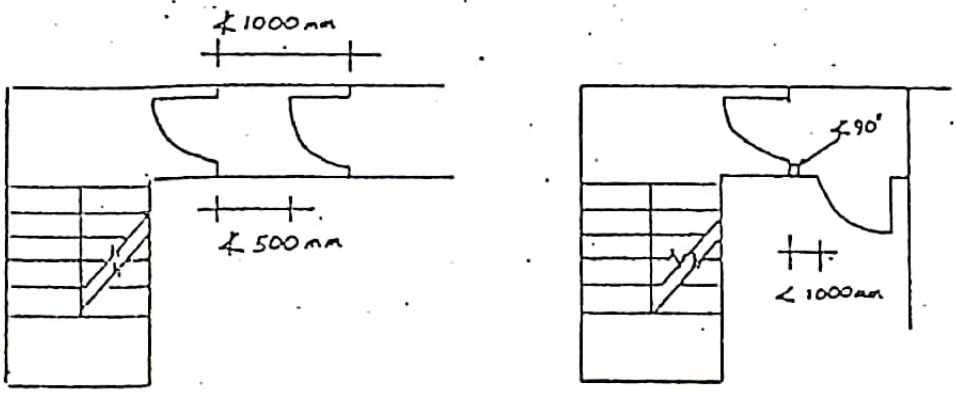
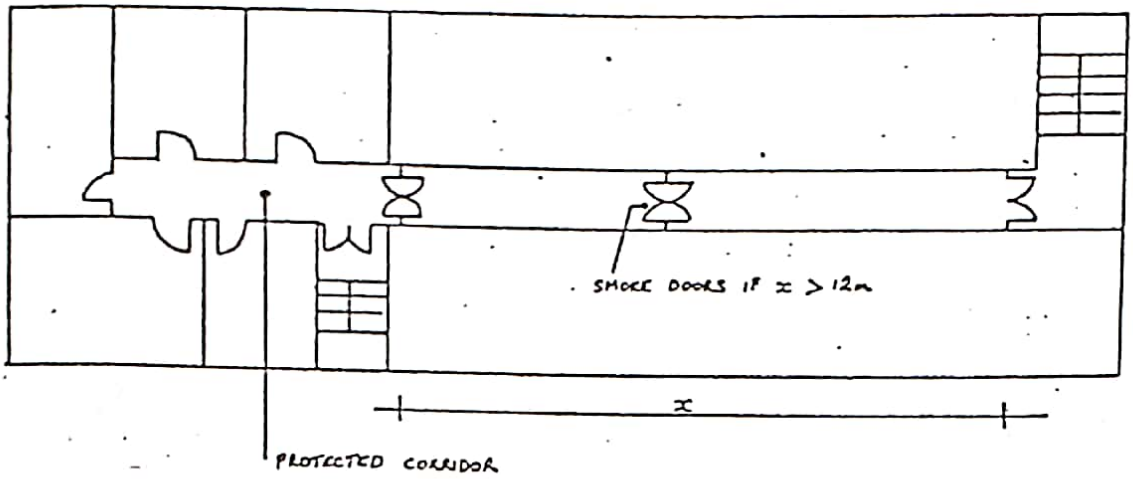


Figure 6.15 Protected lobbies (design)

Corridors

Where corridors are provided, their enclosures should be complete in order to restrict the spread of smoke in the early stages of a fire. In the case of corridors affording escape in one direction only, the enclosures should enable occupants to safely pass a fire and reach an exit, protected stairway or point from which alternative means of escape is possible (figure 6.16). To prevent a corridor connecting alternative exits becoming smoke logged along its length, it is necessary to sub-divide that corridor by a smoke control door except where the corridor is relatively short. Similarly, connecting corridors need to be separated (fig 6.17). Where a storey is provided with two or more exits/escape stairways, smoke doors are required to afford protection to persons escaping along a dead end corridor from any fire within the corridor beyond the nearest storey exit, or on one side or the other of the corridor connecting alternative storey exits (fig 6.16). However, small recesses or extensions are not required to meet the requirments for enclosure and smoke separation (fig 6.18).



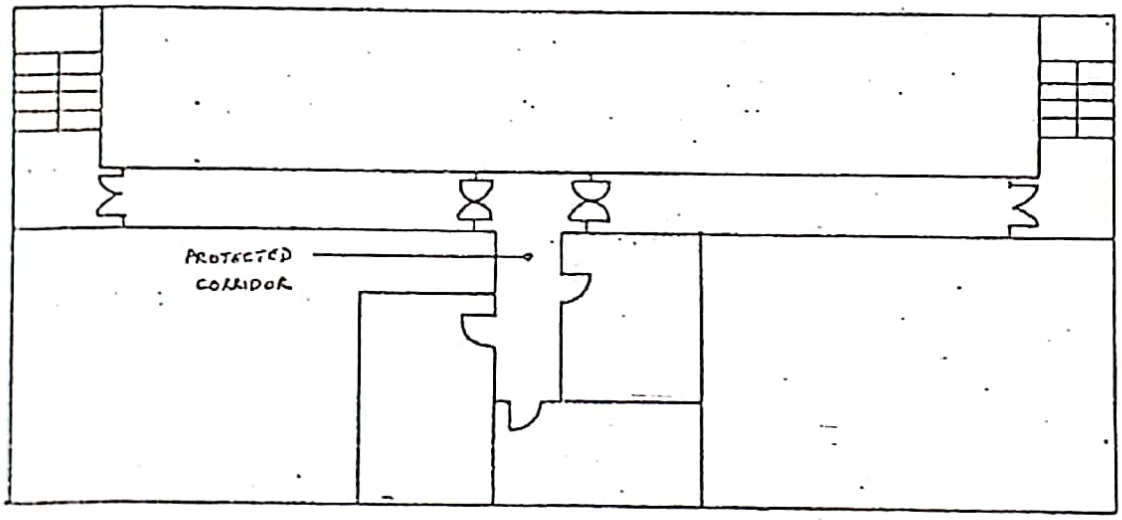


Figure 6.16 Corridors (dead ends)

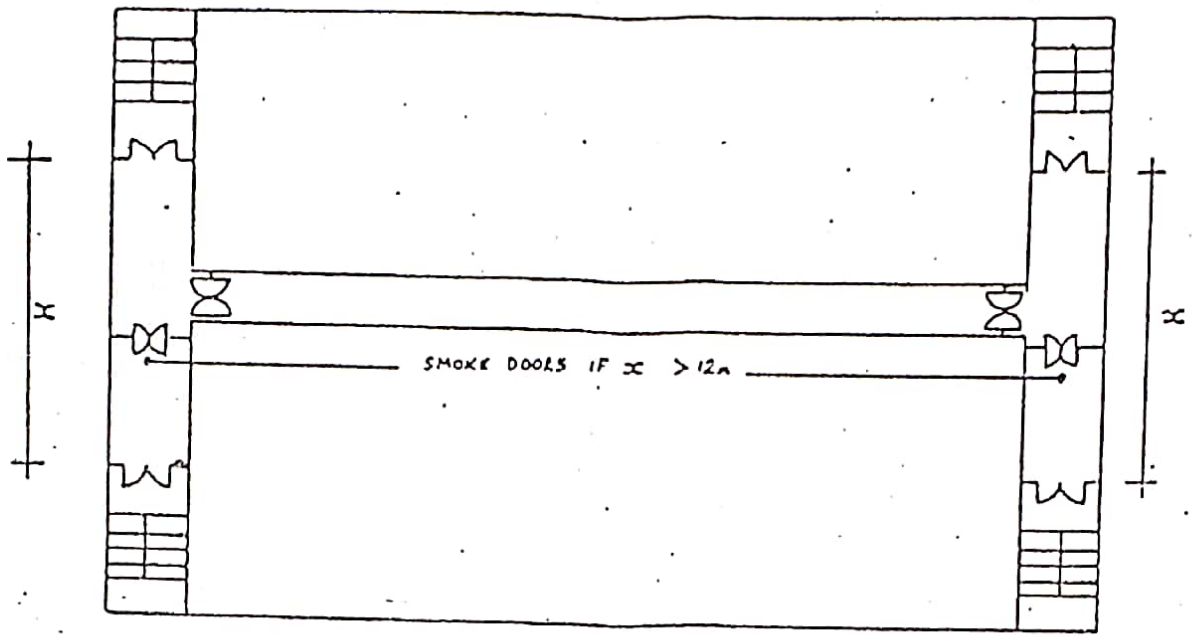


Figure 6.17 Corridors

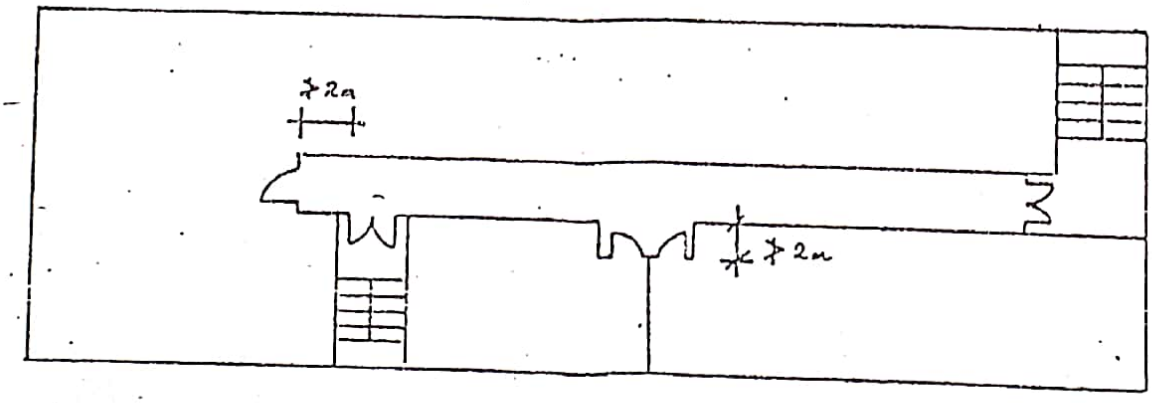


Figure 6.18 Recesses

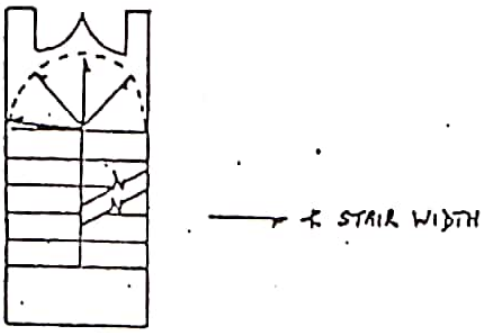
Doors on escape routes

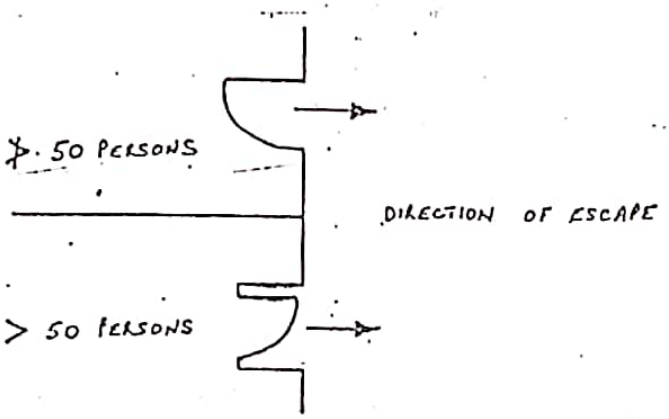
It is essential that in the event of fire the occupants of a building are free to leave the building. Therefore all doors affording means of escape from, and within, a building should not be locked or otherwise fastened in such a way that would prevent escape. In places of assembly, internal doors used by the public should not have any fastenings and final exit doors should be only provided with panic bolts. Where security problems exist, special fastenings (possibly linked to an alarm system) or other solutions may be acceptable to the fire brigade.

Except where a door is used by not more than 50 persons, every door should open in the direction of escape and, to prevent obstructions/ accidents, be arranged to open clear of landings, steps and corridors (figure 6.19). Any door hung to swing both ways should be glazed at sight level to enable people to see if anyone is coming in the opposite direction, and any smoke door across a corridor should be glazed to enable people to clearly see that the corridor continues and whether or not is is obstructed by fire or smoke.

Escape routes across roofs

In general escape routes across a roof are not considered satisfactory except for access to and from plant or other ancillary accommodation situated at roof level. However other acceptable situations may exist where access is permitted across a podium roof or where alternative means of escape is provided between two parts of the same building (eg. from a penthouse flat to the head of an alternative escape stairway). All roof escapes should be adequately defined and guarded, and should be protected from any fire within the same building.





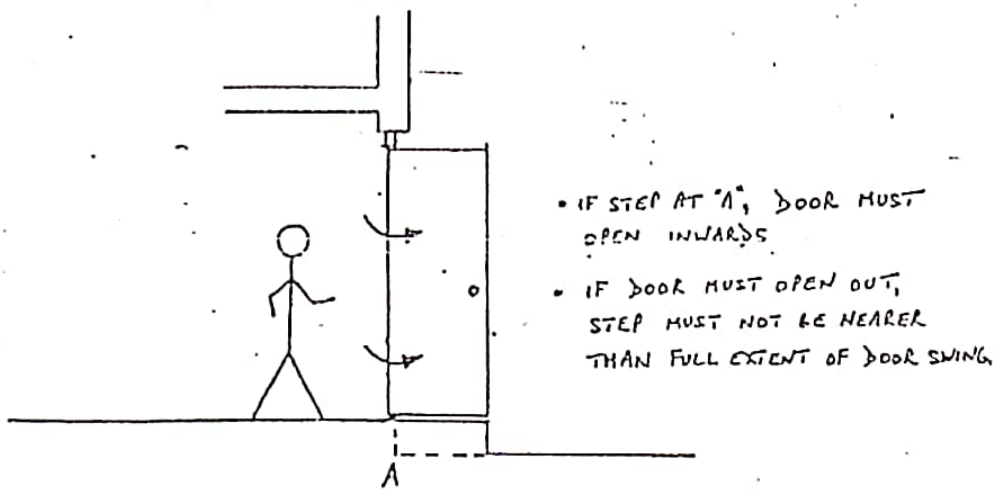


Figure 6.19 Doors on escape routes

Ladders

Portable ladders and throw-out type ladders are not considered suitable for means of escape purposes. Fixed ladders should only be considered acceptable for a small number of able bodies employees in those situations where it is impracticable to provide a stairway, eg. in connection with plant rooms.

Balconies

Connecting balconies are an acceptable means of affording alternative means of escape from individual flats, maisonettes or single family dwelling houses exceeding two storeys in height. Where provided, such balconies should enable persons escaping to be removed from danger - particularly where those escaping may have to wait before being admitted into the safety of an adjoining dwelling.

Glazing

Partitions, doors and windows containing annealed wired glazing based on soda-lime-silica, although being able to satisfy fire resistance in terms of stability and integrity for one hour or more, nevertheless permit heat transmission by radiation which will constitute a hazard to people escaping nearby, and could ignite adjacent combustible materials. No restriction is placed on glazing which can satisfy fire resistance criteria to the full, but glazing which is intended primarily as a barrier against the passage of flames and hot gases only is limited to the sizes given in table 6.6 of the regulations.

CHAPTER 7

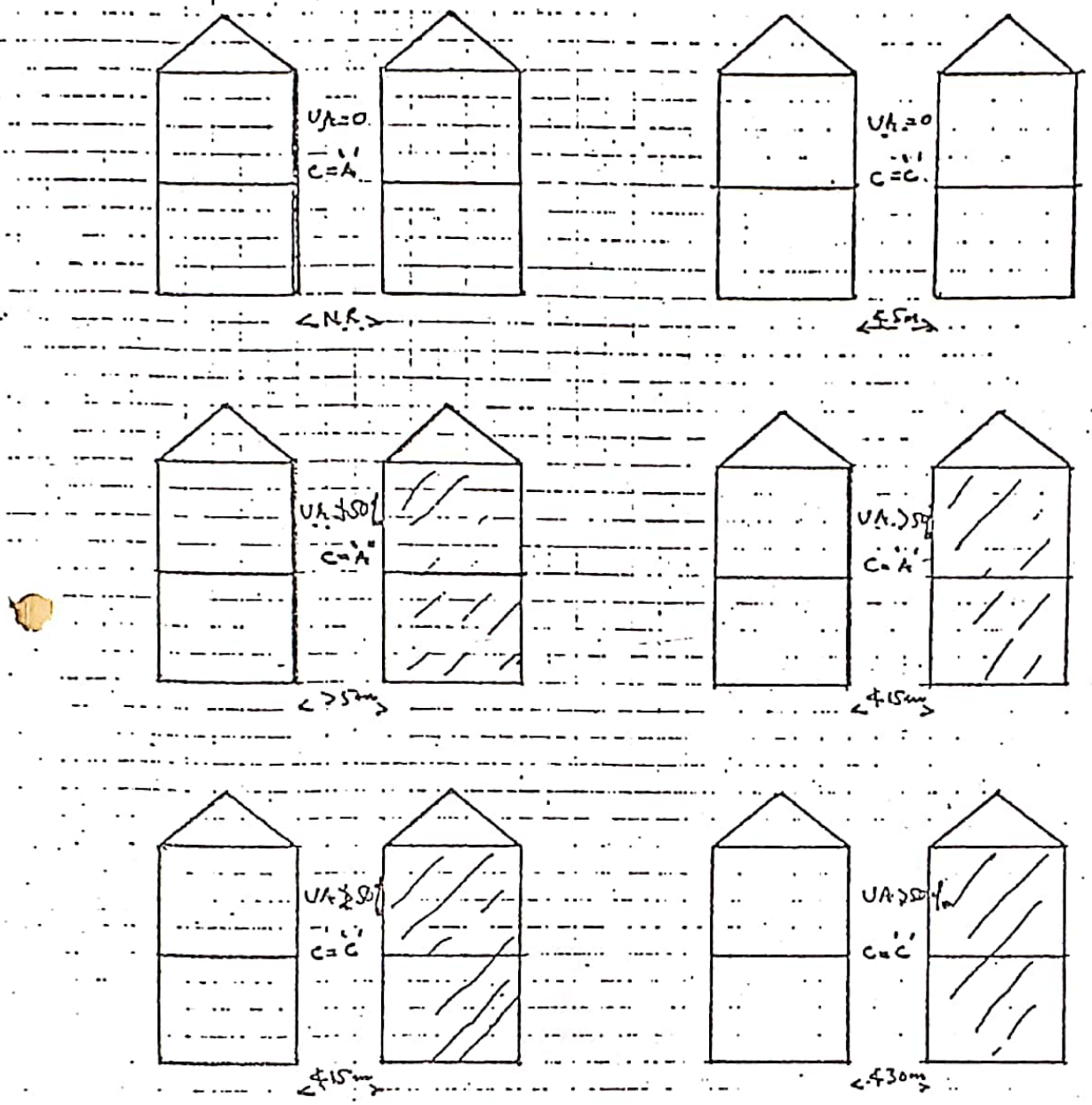
GENERAL REQUIREMENTS

General

Chapter 7 of the regulations translates the fire protection measures and the escape route design principles into precise requirements for various building types. The requirements are specified as if they apply to all buildings but reference should be made to Chapter 8 to see if any amendments are made for a given building type and to Chapter 9 in connection with basements, shopping complexes and high rise buildings. The performance standards are described in Chapter 5 and in a large number of cases constructional specifications are provided and the appropriate references are described in Chapter 12. Alternative performance standards or constructional and installation techniques may give an acceptable level of safety provided the building authority can be satisfied of the adequacy of the proposal.

Separation between buildings

The separation distances given in Table 7.1 of the regulations are intended to prevent the likelihood of ignition of cladding or combustible materials at windows by radiation. Four separation distances are specified in relation to the unprotected area and the nature of the external enclosure as shown in figure 7.1. There is no restriction with imperforate walls, having noncombustible cladding; small openings not exceeding 10 per cent of the facade are ignored. On the other end of the scale, if the unprotected area is more than 50 per cent of the facade and without any control on the cladding materials the buildings must be separated by a distance of 30 m. In between, two steps of 5 and 15 m are



UA — Unprotected area, percentage
C — External cladding, type 'A' or 'C'
N.R. — NO restriction
/// — The other building

Figure 7.1 – Separation between buildings

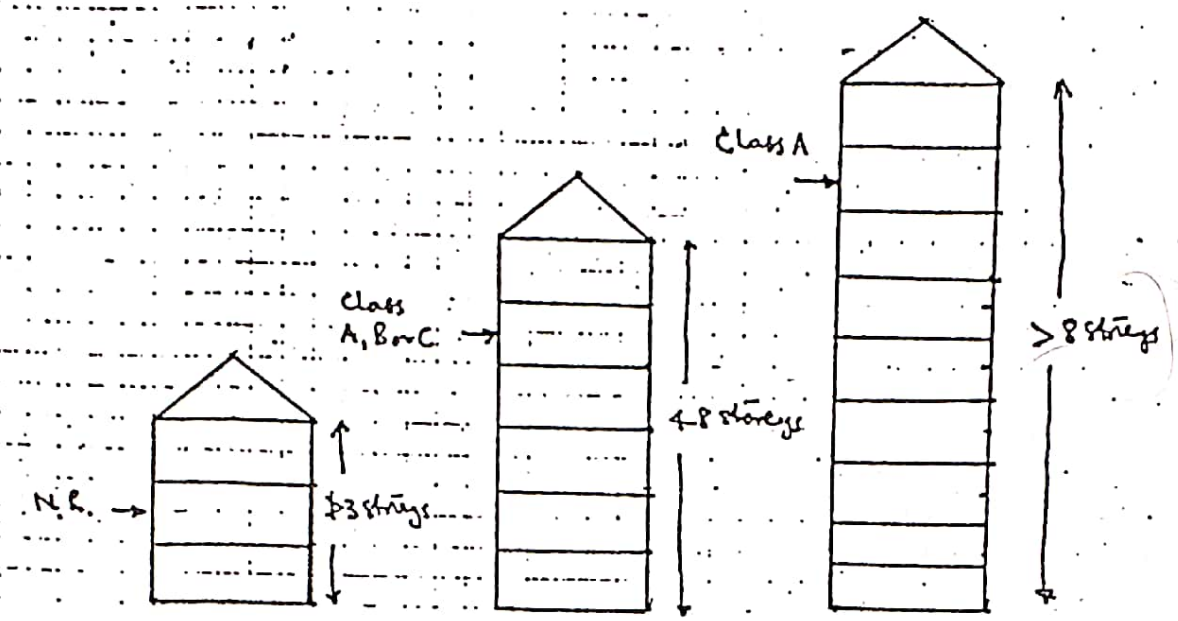
used for different combinations of external enclosure and the unprotected area. As mentioned in Chapter 5 the distances are between building facades, ie a facing building or buildings are assumed to be there. In their absence the restriction is to the boundary and the distance to be used is half the specified distance.

External enclosures

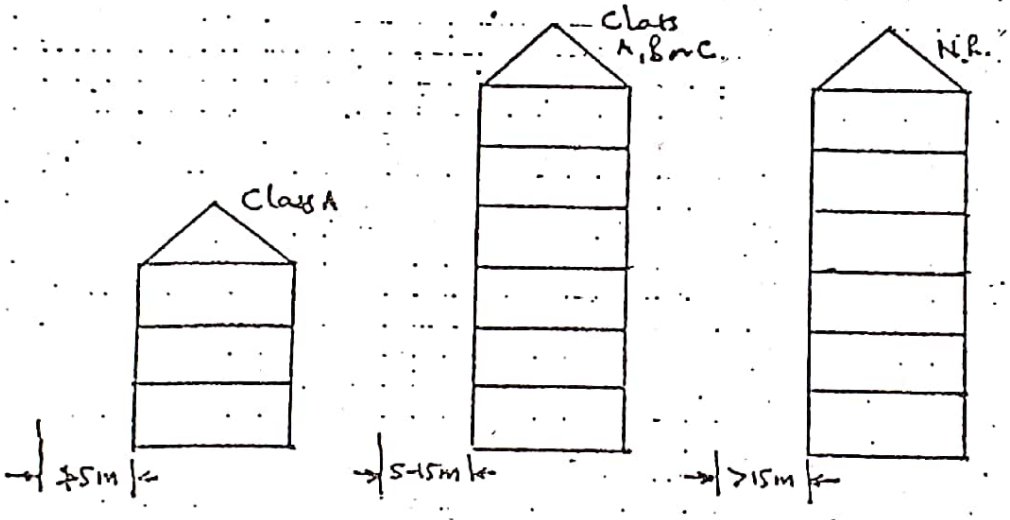
The external enclosure comprises cladding on the walls and the external covering to the roof. If the slope of the roof is more than 70° to the horizontal plane of the building it is treated as a wall. The flammability of the cladding materials has already been controlled in relation to separation between buildings. This requirement is additional to that and is concerned with the hazard of flame spread over the facade of a building particularly by flames emitted from a lower window (fig 7.2). Up to and including three storeys no restrictions are specified; from 4 to 8 storeys it should not be inferior than Class C; and above 8 storeys ie high rise buildings, only Class A (ie noncombustible) facades are allowed.

The nature of the roof covering is also related to the separation between buildings and additional distinction has been made between low rise and high rise buildings. The latter are less likely to suffer ignition of the roof and can have Class C covering material even when close to other buildings.

The requirements for external enclosure apply to window glazing ie if plastics materials are used for this purpose they would be subject to the flammability specification but window frames, facia panels on roof edges and other items of trim are excluded.



Cladding



Roof Covering

Figure 7.2. External enclosure of buildings

Internal surfaces

The nature of the internal surfaces of all buildings, except domestic buildings of types 1 and 2, is controlled according to the use of area and the flammability requirements are specified in Table 7.3 of the regulations and are illustrated in figure 7.3. Maximum protection is required in protected stairways, hence the internal finish must be non-combustible. The next area of concern is protected corridors and lobbies and these must not be inferior than Class B ie low flammability materials with low heat release and smoke producing properties. All other areas can be to Class C standard except in hospitals and public assembly type buildings where the higher class has been specified. Hospitals and other institutional buildings because of special escape problems need more escape time. Assembly buildings have usually a higher risk factor; the occupants are generally not familiar with the place, they can be crowded and with the atmosphere generated by surroundings or the activities the chances of a fire are probably greater.

The exclusion of types 1 and 2 buildings are based on two factors, one the ease of escape from such buildings and secondly the virtual impossibility of preventing householders from altering the finishes and adding decorations and fittings which completely obscure the nature of the original finish.

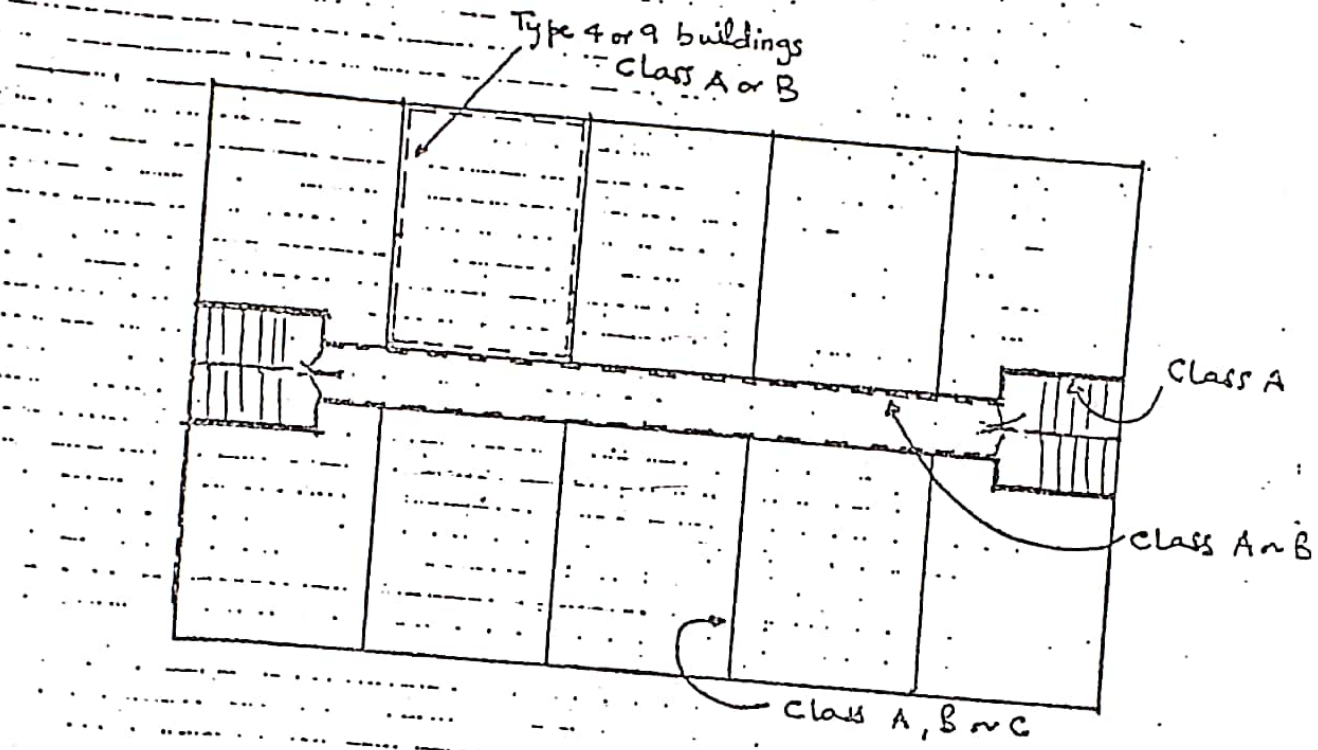


Figure 7.3. Internal Surfaces

Means of escape

The means of escape as far as the design of the escape routes is concerned have been fully dealt with in Chapter 6 of the regulations and the explanatory notes.

Smoke control

The importance of smoke control has been previously mentioned, regulation 7.5 specifies the measures which need to be taken to achieve the objectives. First and foremost is the provision of doors to stairway enclosures, protected lobbies and protected corridors so that the entry of smoke from a fire can be restricted. The doors required should be of smoke control type but in the absence of a test method, normal fire resisting doors are acceptable. In the type of arrangement shown in figure 7.4, smoke from a fire in one of the rooms will try to enter the corridor. If the door has been left open the corridor will quickly fill with smoke, if not, it will percolate slowly until the door is damaged when increased amounts will enter. The smoke will travel at high level towards the stairways and some will leak through the normal door gaps and clearances. If a lobby is interposed the transfer of smoke to the stairway will be further delayed.

In order to keep these areas clear additional measures are needed; these can be for removal or dispersal of smoke or prevention of smoke entry by pressurization. The regulations have specified as a simple measure the provision of 1 m^2 opening at the top of a protected stairway or openable windows at each landing. Permanent ventilation is also specified for protected lobbies for stairways serving basements, enclosed car parks and boiler rooms etc and lobbies to lifts in the basement. Specific ventilation requirements are given for fire-fighting stairway enclosures and fire lift lobbies.

Ventilation shafts can be used for smoke removal from lobbies and stairways and they should have an internal area of at least 3 m^2 or 1.5 m^2 respectively.

It is further required that all above ground floor areas should have provision for emergency ventilation, even when full air conditioning is provided to remove smoke, essentially by the fire brigade personnel when attacking the fire.

Smoke clearance from basements is a specially difficult and critical problem and openings are required in walls or the ceiling which can be uncovered and should be around 2.5 per cent of the floor area. In some cases the openings have to be made from the outside and places where this can be done should be clearly marked. Smoke shafts from basements should be kept separate, as should shafts from boiler rooms, switch rooms and car parks.

Mechanical ventilation can be used provided it is designed to deal with the expected smoke quantities. Normal ventilation systems should prevent recirculation of smoke to other parts of the building. Unless the system has been designed to be flexible enough to deal with smoke removal, it is preferable to shut down the ventilation system serving the fire zone. The installation of smoke detectors in the extract duct is specified to monitor the presence of smoke.

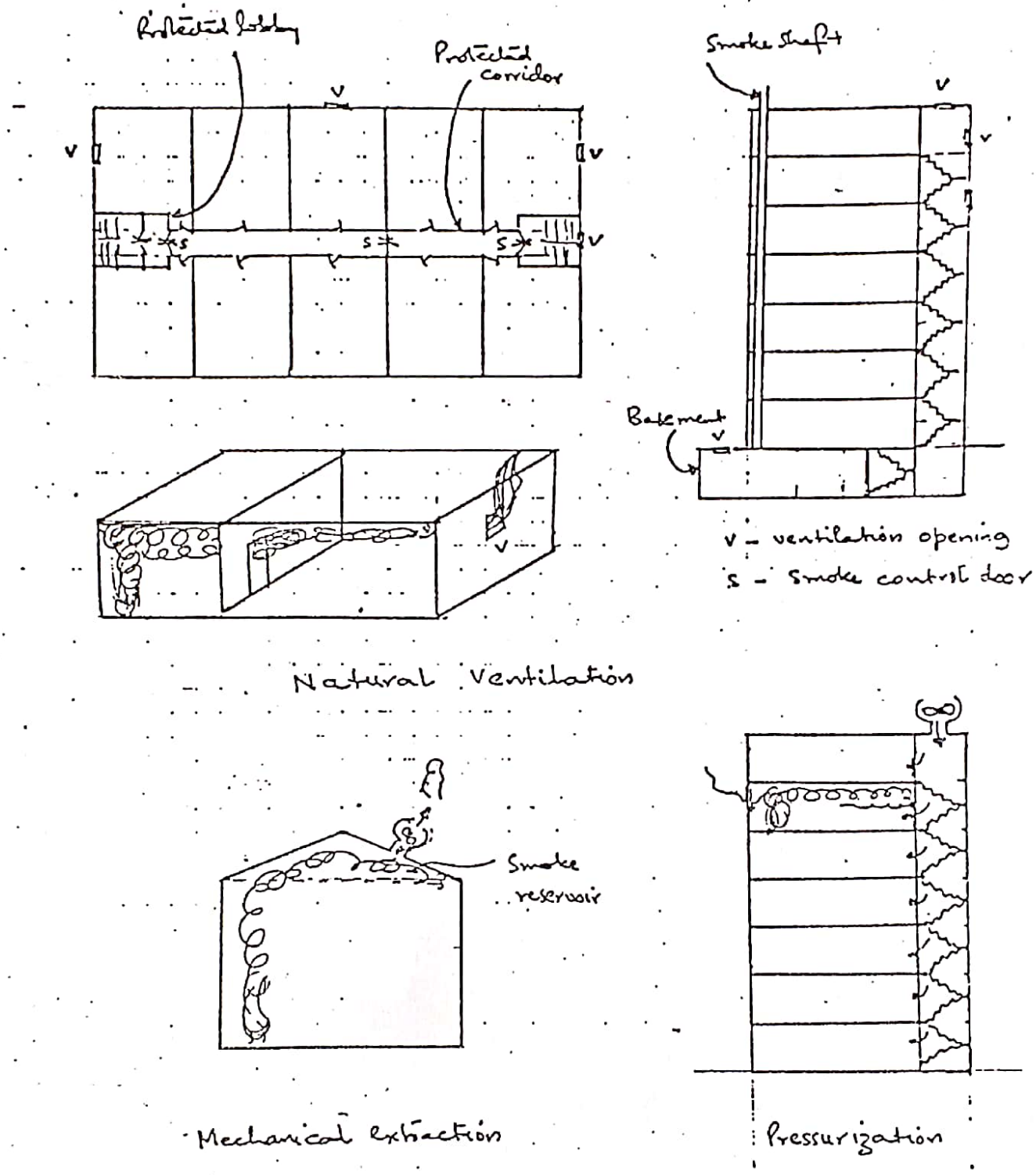


Figure 7.4 Different methods of Smoke control.

Fire detection

Other than building types 4 and 5 where the use of fire detectors is specified in Chapter 8, their provision in other buildings is at the discretion of the approving authority. It is proposed that the layout of each floor area should be examined and if there are obvious risk areas, where a fire may grow unseen, because the area is not occupied, eg a stationery store in an office, or when the fire may grow unseen because of the arrangement of the building eg a department store with hanging furnishings, these should be considered as suitable places for the installation of a fire detection and warning system. This means that many buildings are potential candidates for a detection system but the decision needs to be taken individually. There are some doubts whether simple fire detectors would be of use in domestic buildings. In one country their use is being seriously recommended and data on their effectiveness, reliability, misuse etc is awaited with interest.

Fire doors

Fire doors close openings in fire barriers which have been provided for the movement of occupants and goods. Ideally they should be as good as the wall in which they occur (fig 7.5). Chapter 5 has already drawn attention to the performance of fire doors and the specification given in regulation 5.8.2. ensures that they are judged under the same criteria as a fire wall.

In some buildings certain doors can be of a lower standard because they are primarily provided to provide short term protection against smoke and gases during the early stages of a fire. These are the doors to bedrooms in hotels and institutional buildings (types 4 and 5), doors to the protected stairways in 3-storey houses (type 2) and doors sub-dividing long corridors

to reduce the travel distance to a protected area. A similar requirement is also proposed for doors within flats or maisonettes but in the absence of some assurance that these doors will be kept shut, it is not known how much reliance can be placed on their protective value.

Doors must be in a closed position when a fire attacks them and therefore the regulation requires fire doors to be provided with self-closing devices and with door fittings which will not collapse in a fire and cause the door to malfunction. The normal purpose of the door closer is to move the door from an open to a closed position where it is retained by a latch. However certain doors do not possess latches eg double swing doors, in such cases the door closer must also keep the door in the closed position when it is being attacked by fire. Hook bolts and wedges etc to keep the door in an open position are not permitted but electro-mechanical hold open systems may be used as these can be linked to alarm systems or manually operated overrides to close the door on the occurrence of a fire. Areas where there is considerable traffic and the door cannot be kept open all the time for reasons of, for example, privacy, may require the use of closer systems provided with free swinging facilities where a signal operates the closer mechanism and the door is automatically closed. Failure of electric supply should also close the door automatically. All fire doors should carry a notice indicating their function and a mandatory request to keep them closed or locked (for doors to cupboards, ducts etc) when not in use.

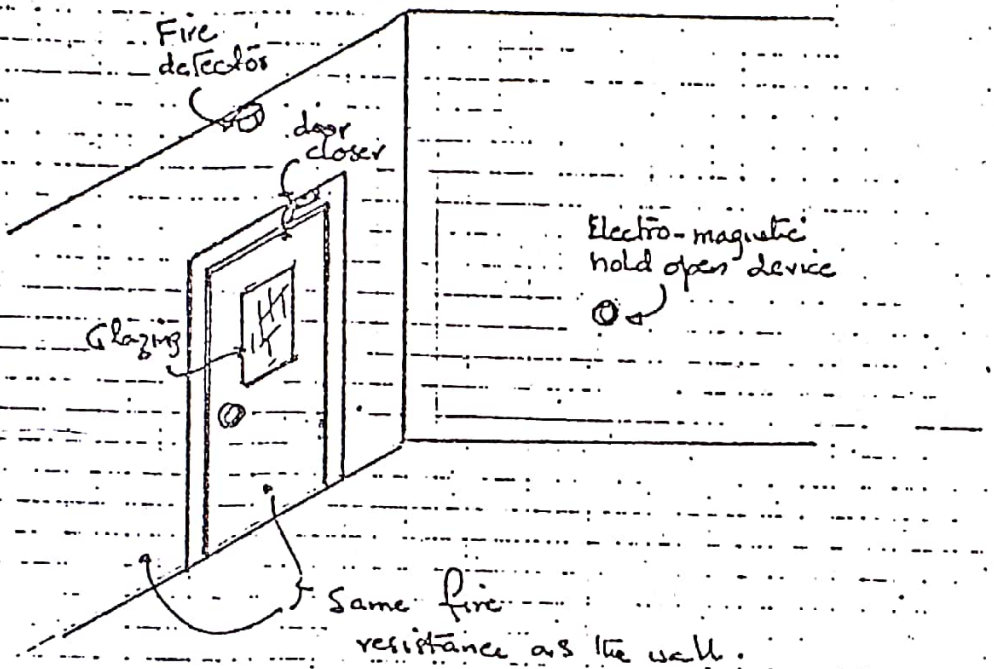


Figure 7.5 Fire doors

Lighting

Except for building types 1 and 2 where escape is considered to be easier, the regulations require attention to be paid to the provision of adequate lighting for escape purposes. Lighting intensity should be sufficient so that occupants have no difficulty in seeing their route and the storey exits, and if the normal lighting system fails, emergency or escape lighting should come into operation automatically. Such lighting may be restricted only to parts of the escape route. Lighting is also needed to illuminatefire-fighting equipment and to show the location of call buttons. Safety signs should also be illuminated particularly those directing the occupants to a place of safety.

Signs

The regulations require all buildings other than types 1 and 2 to be signposted so that occupants are absolutely clear on the route they should take in case of a fire. Adequate signs are most important in buildings where the occupants do not use the escape routes for normal entry or exit from the building. For example in high rise buildings lifts are a common means for travelling from floor to floor yet in a fire they may be immobilized and are not recommended for escape purposes. Hence the occupants need to be able to realise quickly the safe route available to them. The escape route signs should ensure that the occupants will make their way to the storey exits rather than the lift.

Direction signs in words or symbols should be easy to see and follow, arrows are used frequently for this purpose with a symbol indicating a person moving quickly to the exit. Low level repeat signs are needed when smoke obscures the high level signs. Experiments have shown that

signs on floor are easy to follow. Provision of warnings against unsafe activities, prohibition of certain actions and marking of fire equipment come under the heading of fire signs. Although internally illuminated signs have been specified only for assembly buildings, they could be used with advantage in some other buildings as well.

Compartmentation

The principle of compartmentation has been described in chapter 5 and the regulations have taken rather a simple approach to its specification as shown in figure 7.6. Fires in single storey buildings are easy to deal with hence a compartment of 2000 m^2 is permitted. However to prevent an excessively heavy fire load which could result in storage buildings (types 13 and 14), an additional limit of 6000 m^3 on volume has been introduced. For multi-storey buildings smaller compartments are allowed with a floor area of 600 m^2 over one or two floors, but compartments cannot be more than two floors deep. Basements are considered to require more restrictions and the compartment size has been reduced to 300 m^2. Due to beneficial effects of sprinklers on fire severity where these are provided in accordance with the specification in the regulations, the compartment sizes can be doubled.

The regulations also specify compulsory compartmentation in buildings, firstly domestic buildings should be separated from each other by compartment walls and, where appropriate, compartment floors. This has the effect of requiring each flat or maisonette in buildings type 3 to be a fire compartment. All basements should be separated from each other by compartment floors, including the ground floor. All protected stairways should be compartments and different types of occupancies should be separated by compartment walls and floors. In building types 3,4 and 5 not exceeding

8 storeys in height alternate floors should be compartment floors; in buildings above 8 storeys in height each floor should be a compartment floor.

The aim of these requirements is to keep the size of a potential fire small, to protect the vital stairways from the effects of a fire and to prevent structural collapse in high rise buildings.

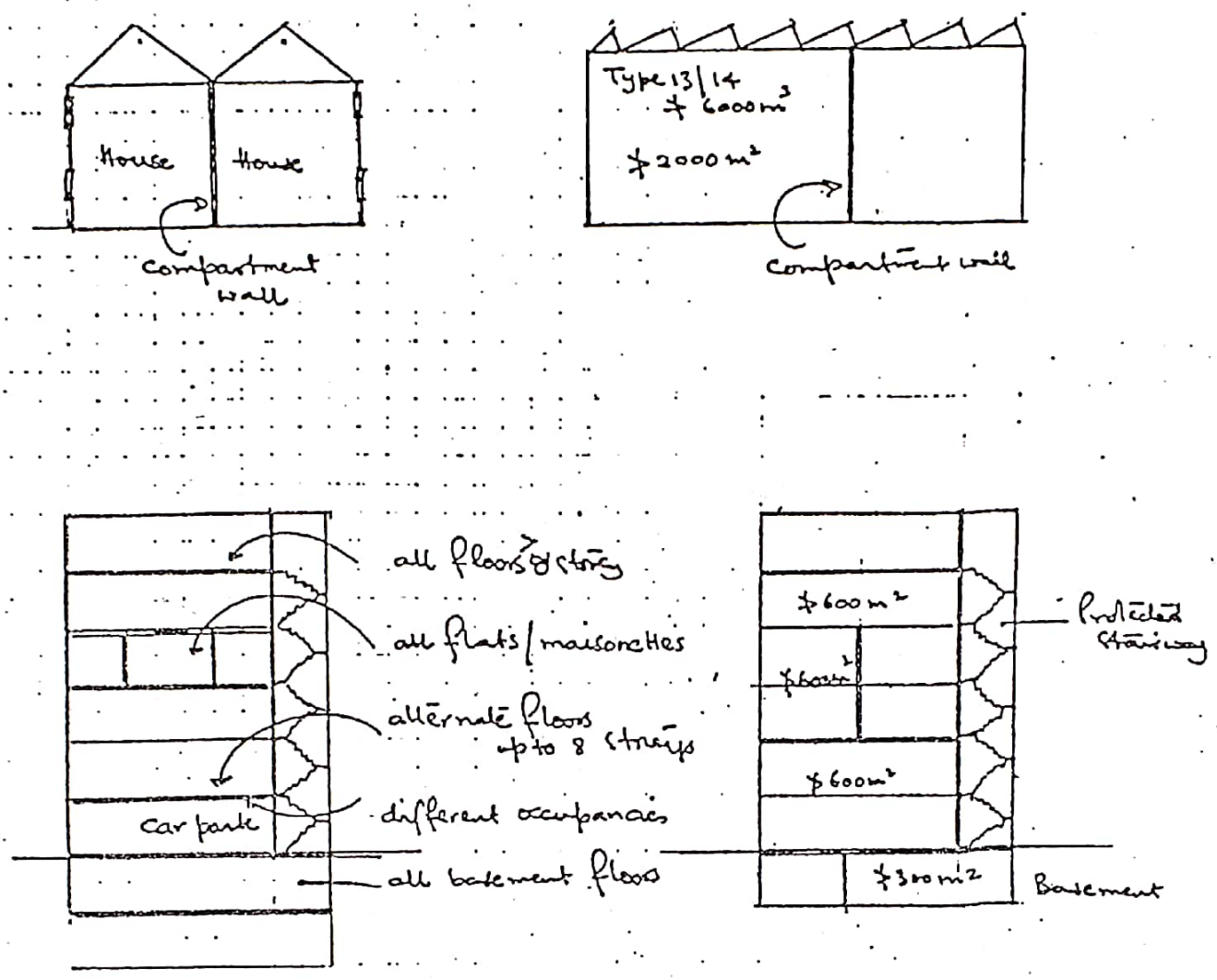


Figure 7.6. Compartmentation

Fire resistance

The bar chart in figure 7.7 shows graphically the fire resistance requirements for different types of buildings. It will be seen that for buildings from 2 to 4 storeys in height the fire resistance requirements range from ½ to 2 hours and represent the norm on the basis of the expected fire load density. The fire resistance requirements are increased as buildings become taller in order to prevent serious structural damage which could result in catastrophic collapse or even with a localized fire require extensive replacement. Requirements are also increased for basements because of the difficulty of fighting fires in such areas. However requirements for single storey buildings have been relaxed because of the ease with which ground level fires can be controlled.

The additional requirement for noncombustibility applies for constructional elements of building types 3 to 8 of more than 1 storey in height and building types 9 to 12 of any height. Noncombustibility restriction is applied to the main construction of these elements and does not include linings and other finishes which are not essential for obtaining fire resistance. It would also seem acceptable to permit insulating materials in the construction provided they are protected from direct effects of the fire and are not inferior than Class B according to regulation 5.3.2.

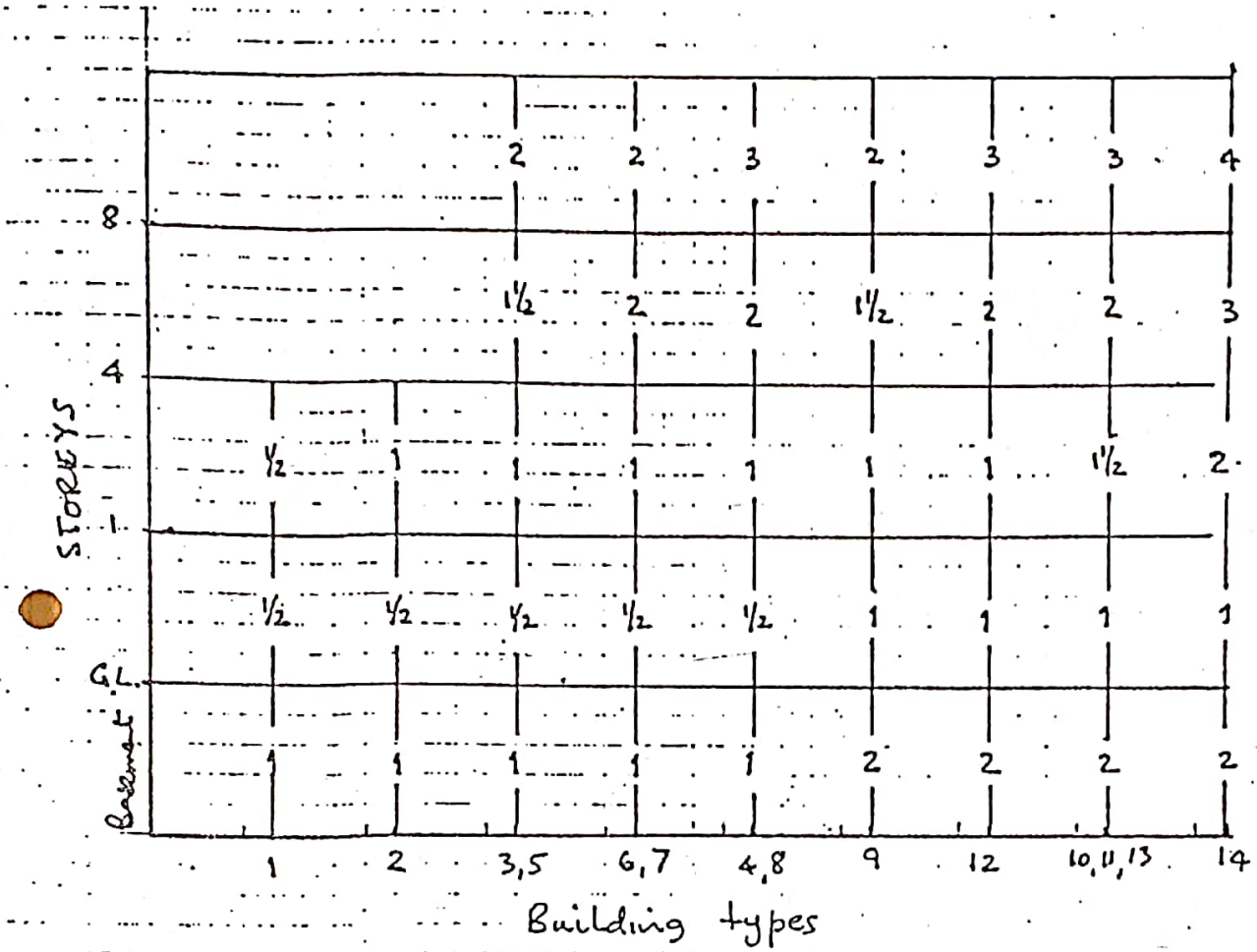


Figure 7.7 Fire resistance requirements for different building types in hours

Penetration of fire barriers

Regulation 7.13 has the primary aim of ensuring that fire resistance barriers erected in accordance with regulation 7.12 are not weakened by the presence of services and other penetrations. Figure 7.8 illustrates the method of dealing with pipes and ducts, up to 35 mm size there is no restriction provided the pipes are fire sealed (regulation 5.13); above that size combustible pipes are allowed for special uses where water traps occur (toilets etc) or suitable metal pipes in other situations up to a maximum diameter of 100 mm. Above that size and for ventilation ducts the use of fire dampers is specified where the ducts pass through a fire barrier, be it a wall or a floor.

The alternative to individual protection of pipes and ducts is the use of service shafts to enclose a group of these. The enclosure of the service shaft should have the same fire resistance as the floors and walls to which it adjoins. Local connections to services are made in accordance with the limitations given in the previous paragraph. Certain building usages have a need for a large number of services in the building, eg hospitals, laboratories etc, and it is useful in such cases to consider the problem at the design stage and group together services through special vertical or horizontal ducts and minimize the points of weakness.

Extract ducts from kitchens in buildings need to be kept separate from others, as they collect fatty deposits and are prone to easy ignition. Any obstruction placed in the duct, eg fire dampers, will become coated in due course and become inoperative. Ideally the deposits should be filtered at an early point and not allowed to enter into the duct system.

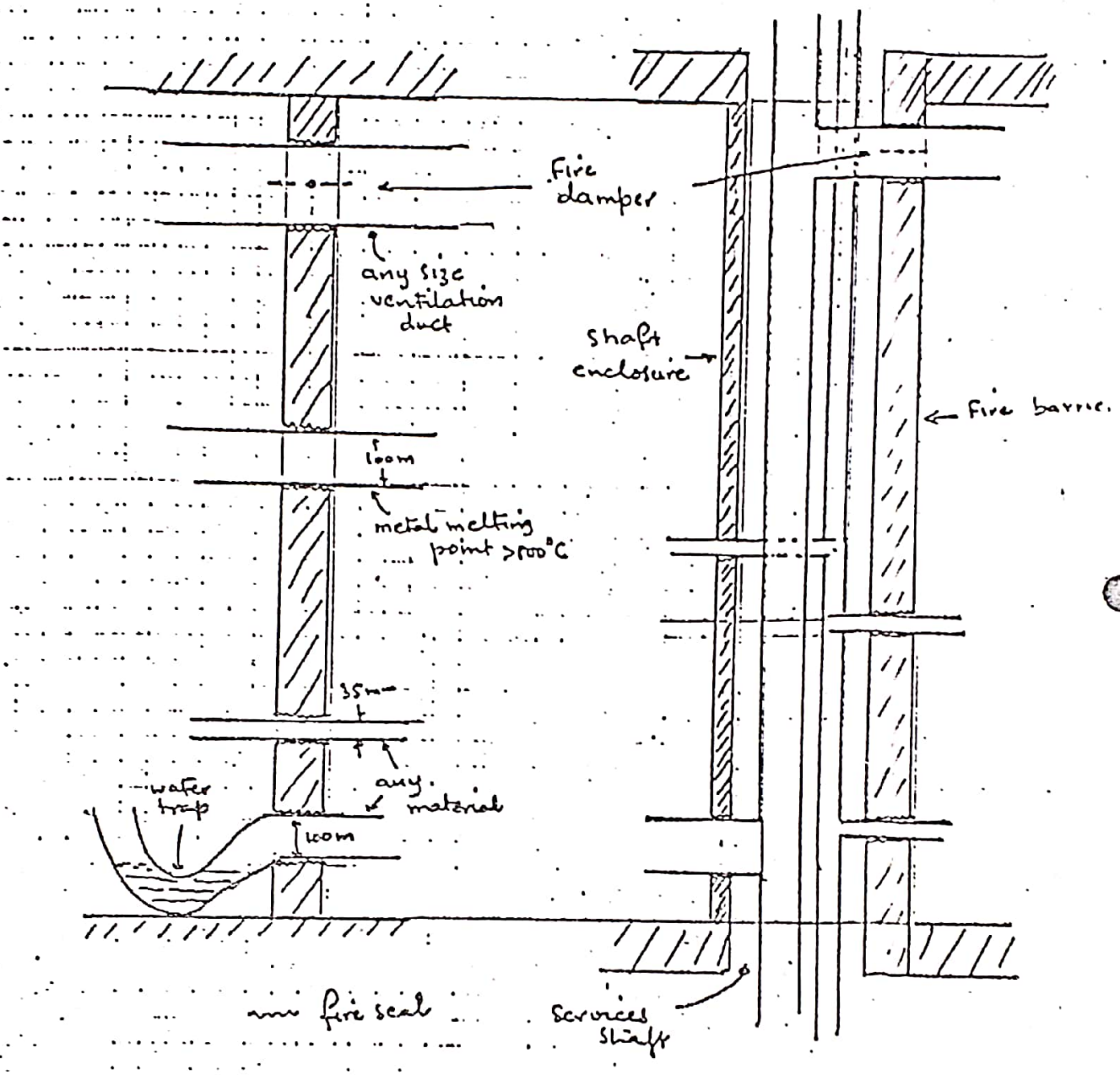


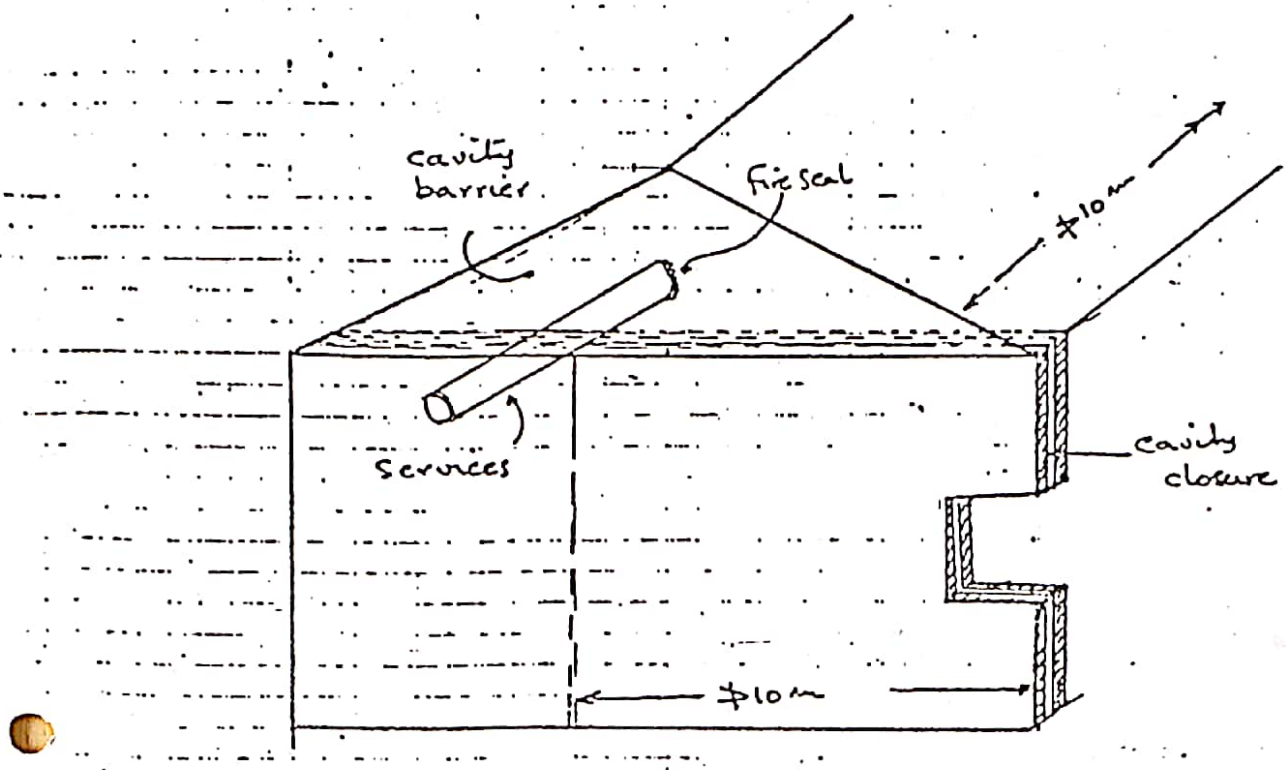
Figure 7.8 Penetration of fire barriers

Cavities and concealed spaces

Another weakness which can exist in fire resisting constructions is due to the presence of cavities and concealed spaces. Regulation 7.14 provides requirements to prevent unseen spread of fire and by-passing of the fire barriers through weaker parts of the system. Two main aspects of the requirements are sealing of gaps around openings and at the edges of all constructions which have cavities. Figure 7.9 shows that with hollow constructions, each individual element should have no edges without a cavity closure and no cavity longer or wider than 10 m.

The concealed spaces behind ceilings are also a potential area for fire growth and spread and once a fire enters such areas it could spread to remote parts of the building connected by such spaces. The general rule of 10 m as a maximum linear dimension of the space is applied here and a requirement for a cavity barrier specified. The cavity barrier is a fire resisting construction capable of preventing the passage of hot gases and flames. The cavity barrier can be an extension of a fire barrier below the ceiling or it can be separately erected. In either case the fire resistance should be such that the fire will not penetrate to the other compartment in a shorter time than through the normal fire barrier and where a large cavity is being subdivided the fire resistance of the cavity barrier should not in any case be less than 30 minutes.

As cavity barriers have to be attached to irregular surfaces in the ceiling space and often services have to pass through them, care is needed in their design and installation to retain resistance to the passage of flames and hot gases.



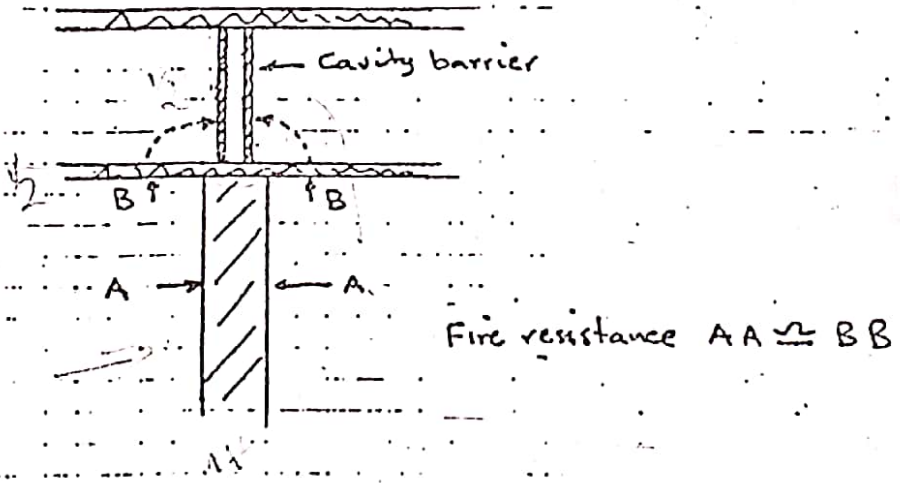


Figure 7.9 Cavities and concealed spaces

Lifts

Regulation 7.15 attempts to ensure that lifts in buildings will not lead to the spread of smoke and fire from floor to floor. Lifts are permitted to be located within the enclosures to a protected stairway or service core, otherwise each lift shaft or bank should be enclosed in fire resisting construction with suitably designed doors. The regulations also require the lift circuits to be well designed, with manual override facilities for the fire brigade use.

Manual Fire-fighting equipment

Portable fire extinguishers and hydraulic hosereels are two types of manual fire-fighting equipment recognized by the regulations. Recommendations for their provision are given in Chapters 8 and 9 for each type of building. Portable fire extinguishers are of maximum use in trained hands and their effectiveness can be nil if the operator has no experience of handling them. Hence their specification where trained personnel are not likely to be available, is of doubtful value.

Fire extinguishing systems

The regulations recognize the use of various systems but only sprinkler installations are considered in detail and concessions allowed on the maximum permissible compartment size where they have been provided. The installation of sprinklers must be to a recognized standard, the regulations quote two specifications, one European and the other American. There are some differences between the two but

both can be considered to be equally effective provided they are completely followed. It is not possible to use one for part of the installation and switch to the other for another part of the same system.

Water supplies for firefighting

The regulations draw attention to the need for the provision of water for fire-fighting purposes and refer to a publication where guidance is given on the siting and sizing of such systems. However the system must be compatible with the fire brigade needs and details of design will be subject to the guidance given by the local fire brigades. The building designer should consult them at an early stage.

Fire brigade access

This is another area where the precise needs have to be agreed with the fire brigade and the rules given in regulation 7.19 have been found to be suitable in some other countries. The appliances in use by the local brigades, the road layout and the prevailing traffic conditions have to be considered when making provisions for the fire brigade access.

Site and building plan

The information specified in 7.20 is considered to be essential information to enable the fire brigade to perform their task of rescue and fire control when they arrive at the scene of a fire. Such information is imperative for large complexes and for buildings in city areas where it is essential to prevent a fire becoming a conflagration as large number of lives may be at risk. Such buildings should be subject to regular inspection by the fire brigade when they can ensure that all relevant information is available and correct.

CHAPTER 8

SPECIAL REQUIREMENTS

General

Each section of this chapter has been numbered to correspond to a building type and includes variations from the general requirements in Chapters 6 and 7. This chapter should be consulted to determine the amendments to the requirements for the building type under consideration but basements, high rise buildings and shopping complexes are dealt with in Chapter 9 of the regulations.

Types 1 and 2 - Houses

Type 1 buildings have requirements for separation, external enclosure, fire resistance and cavity barriers as far as the construction of the building is concerned. Requirements for hydrants and fire brigade access have also to be considered. Type 2 buildings because of the additional height need to have provision for a protected escape route. The staircase has to be enclosed in a ½ hour fire resisting construction with 20 minute fire resisting doors. Figure 8.1 shows two acceptable arrangements with the stairway located on the external wall or within the building.

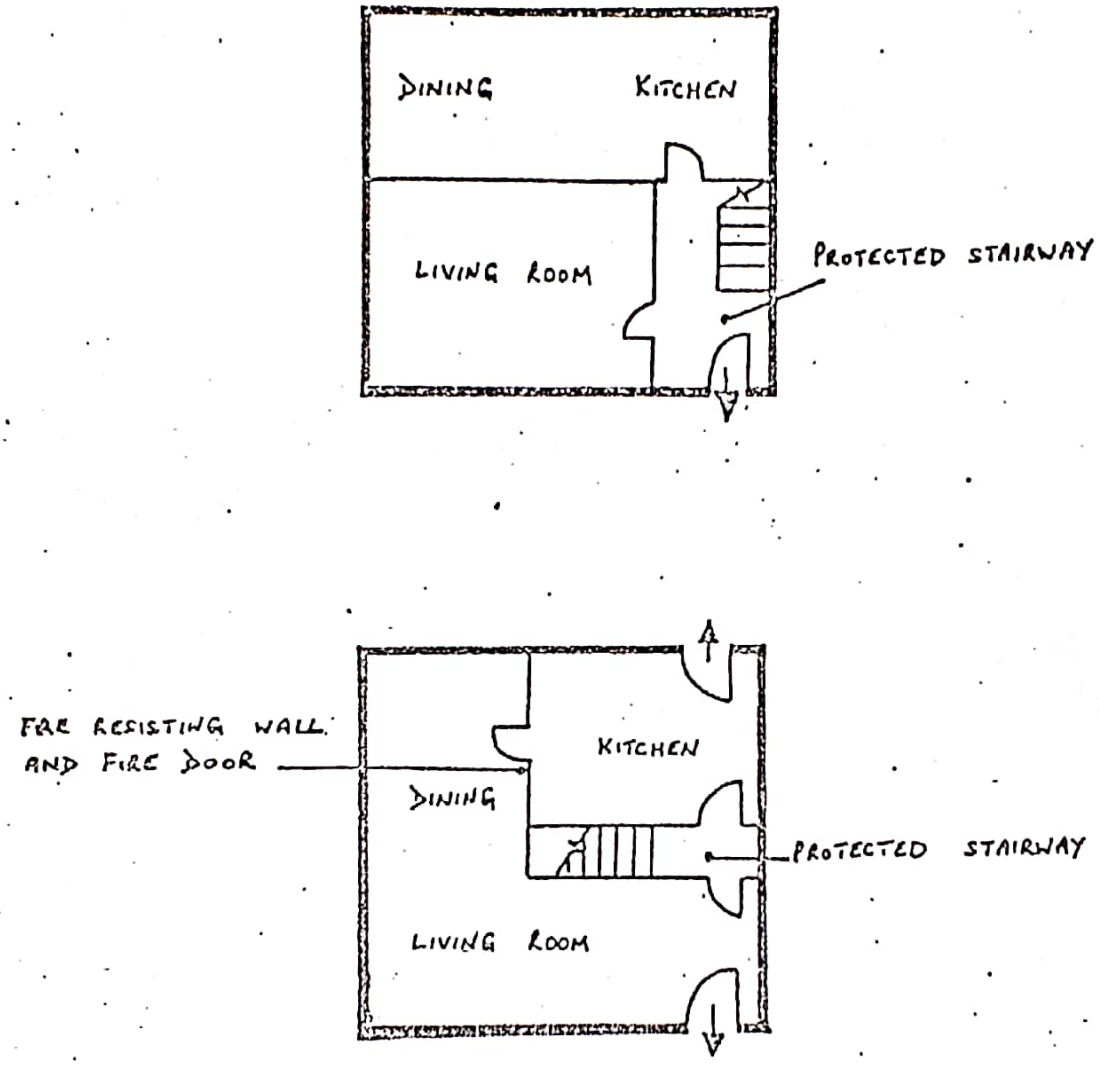


Figure 8.1 Type 2 houses

Type 3 - Flats and maisonettes

Type 3 buildings owing to the larger number of occupants at risk require more elaborate escape provisions. Within each flat (fig 8.2) the travel distance from any bedroom to the external door is limited to 7.5 m, otherwise alternative exits have to be provided. The same limitation is applied to flats where entrance is obtained at a lower level and stairs lead to the internal hall of the flat (fig 8.3). The main concern is to ensure that the occupants in the bedrooms will not become trapped and consequently if the distance they have to travel to the front door is more than 7.5 m or their escape through an internal hall is likely to be cut off, alternative routes have to be provided. Figure 8.4 shows access from one bedroom to a balcony or an alternative internal route and pass doors connecting other bedrooms to this bedroom.

In the case of maisonettes where the bedrooms are not at the same level as the entrance to the maisonette, the internal stairway needs to be enclosed with a fire resisting door either at the head or the foot of the stairway depending upon the access (figs 8.5 and 8.6). Where the bedrooms are not on the access floor, an alternative route from bedrooms is required.

Travel distrances from the flat or maisonette to an escape stairway or a smoke control door across a corridor is also reduced from that in regulation 6.2 to 4.5 m for the first stage to a place of safety, and to 15 or 30 m to the storey exit depending on whether single direction or multi direction routes are available (figure 8.7). Where no smoke doors are provided the 15 m limit on travel distance is to the storey exit for one stairway system and to 40 m with two or more stairways (figure 8.8). Where every dwelling on the floor has an alternative escape from the flat further relaxation to 40 and 50 m for travel distances is allowed for single and multi-directional escape respectively.

Any glazing on escape routes comprising balconies and where occupants may have to pass with fire on the other side, should be at a height of 1100 mm or above to enable occupants to escape, crouched if necessary.

Corridors serving the flats should be ventilated either by permanent openings (PV), openable ventilation (OV) or automatic openable ventilation (AOV) depending upon the number of stairways, and the length of the corridor. Openings in the end walls (figs 8.7 and 8.8) show the position of the vents.

In mixed occupancy types, lifts serving flats and maisonettes and at least one of the escape stairways should be separated from other occupancies. If the stairways are shared, entrance from the other occupancies should be through a protected and ventilated lobby.

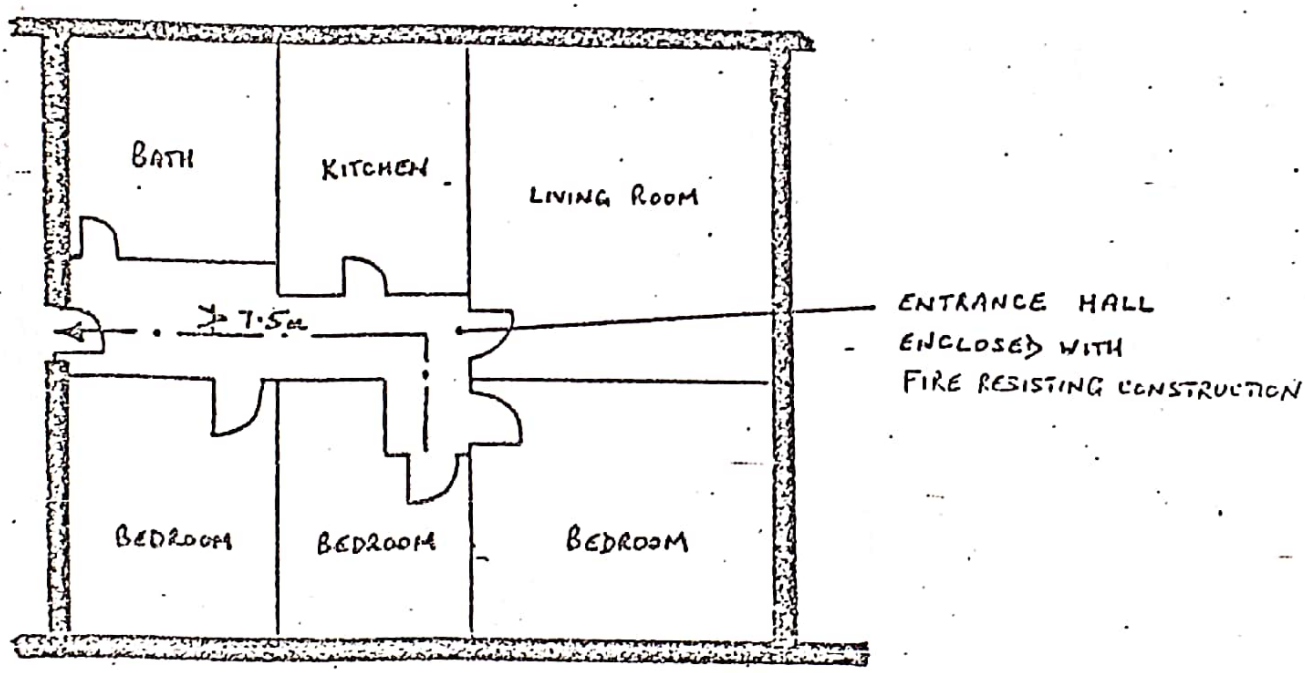


Figure 8.2 Flats with a single exit

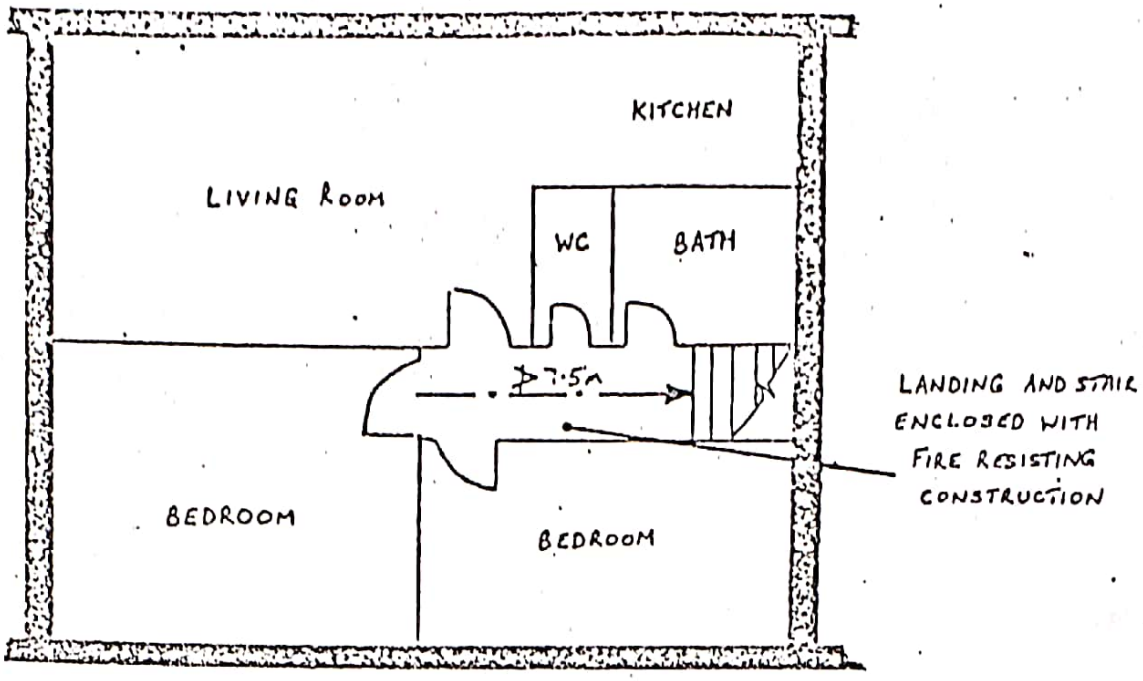


Figure 8.3 Flats with a single exit (stair access)

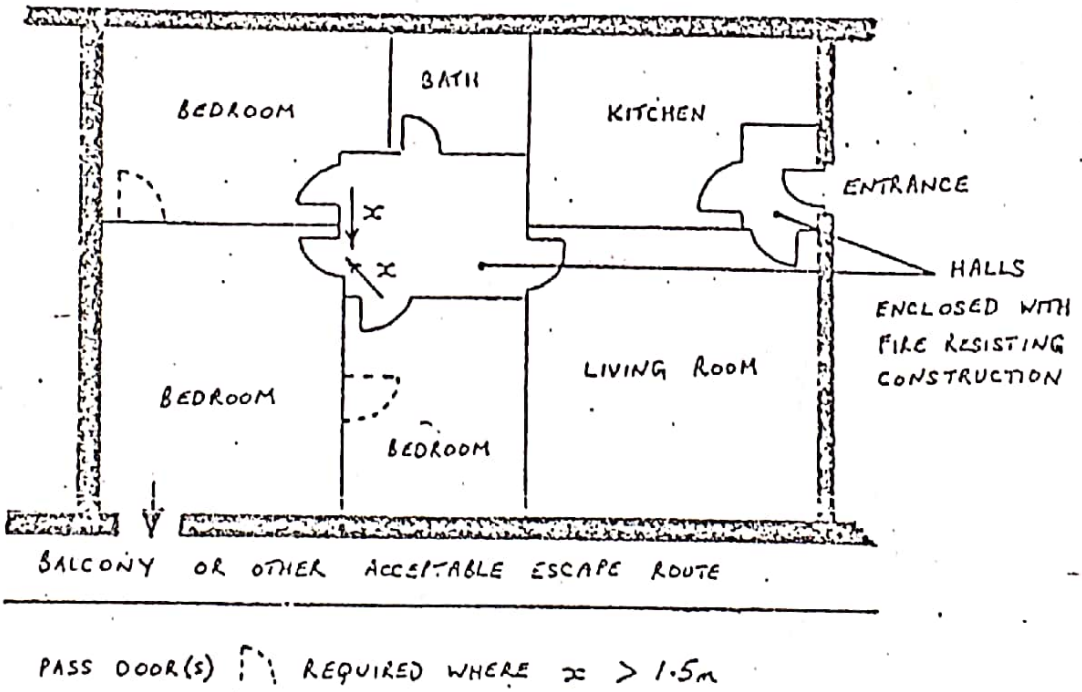


Figure 8.4 Flats with an inner bedroom lobby

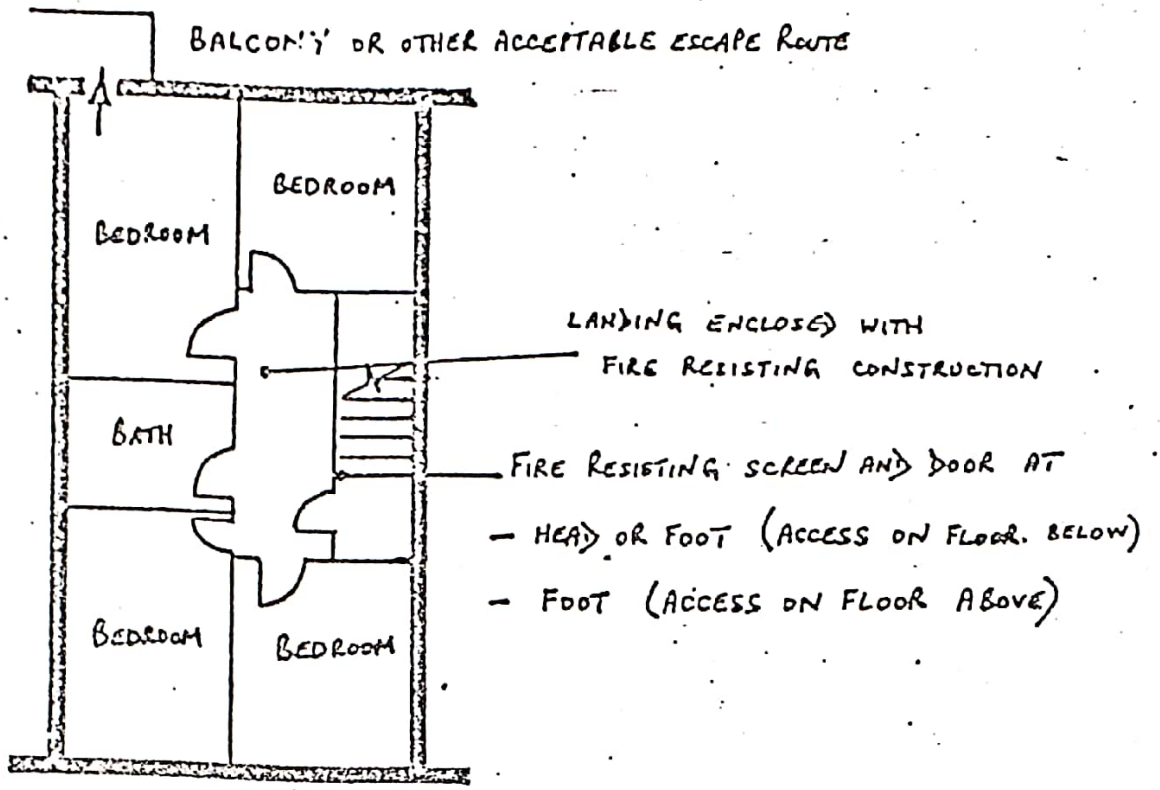


Figure 8.5 Maisonettes

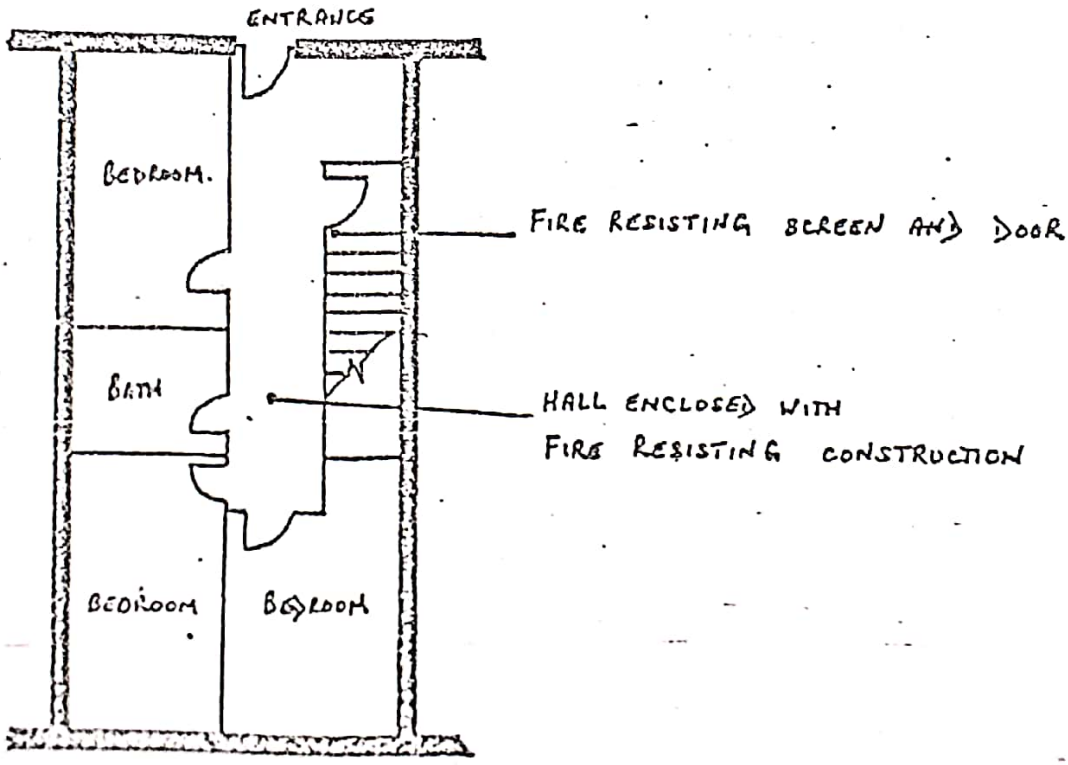
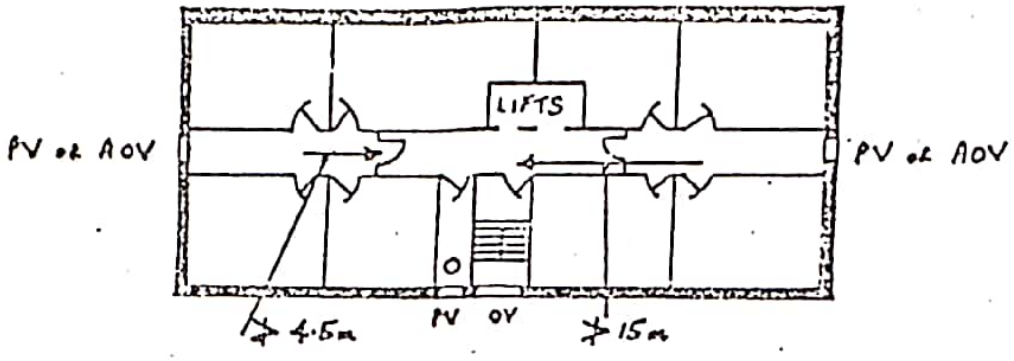


Figure 8.6 Maisonettes (living accommodation below access level)



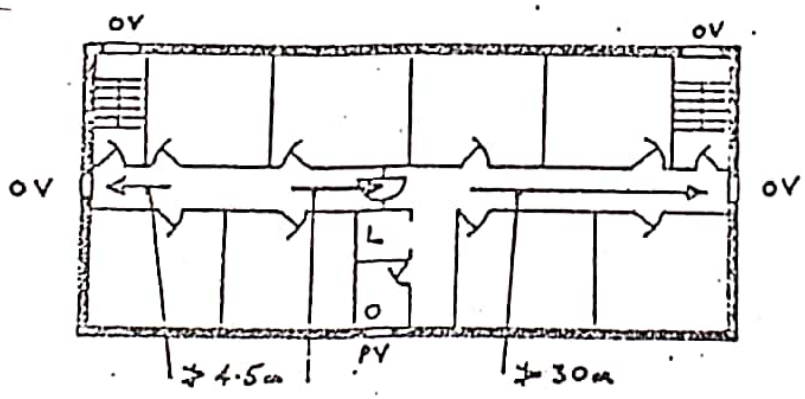
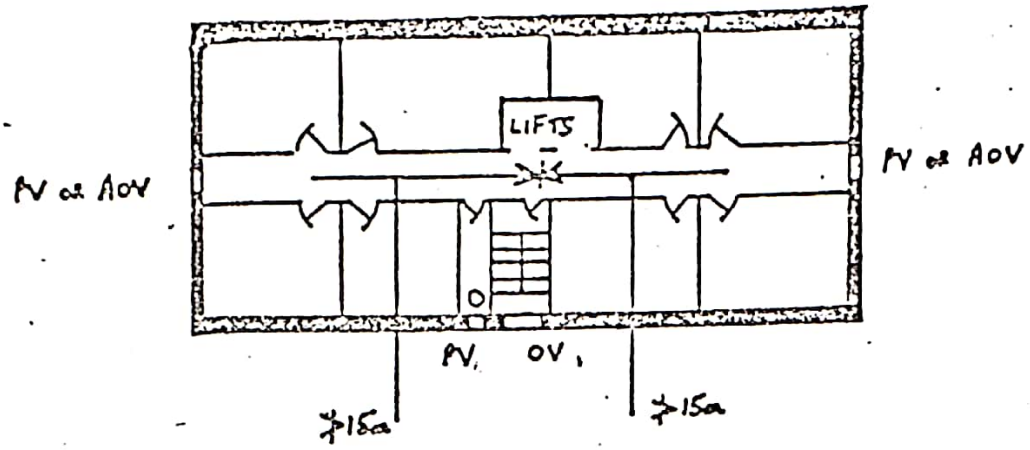


Figure 8.7 Type 3 buildings (access corridors with smoke doors)



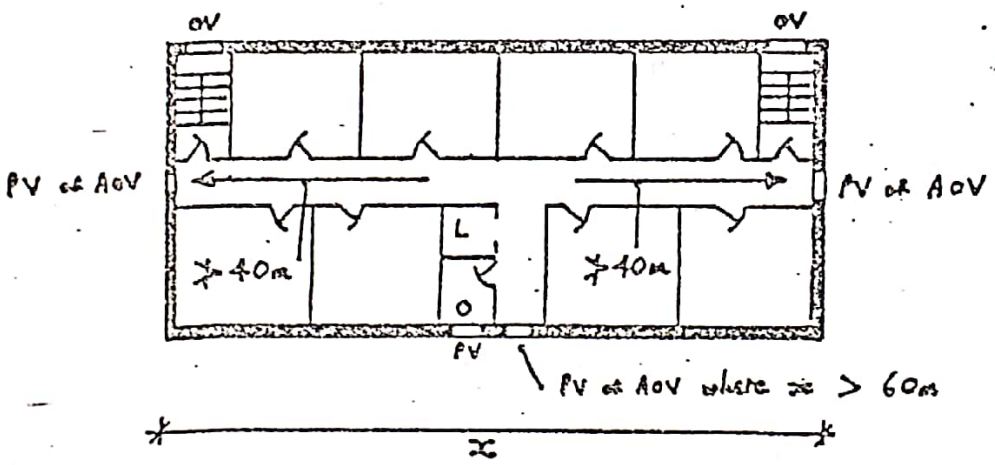


Figure 8.8 Type 3 buildings (access corridors without smoke doors)

Type 4 - Institutional buildings

The main concern with such occupancies is due to the lack of mobility of the occupants due to age and infirmity in hospitals or restrictions on movement as in prisons. The earliest knowledge of a fire is essential in such cases and regulation 8.4 requires the provision of a fire detection system. Where the buildings are used by old people or the occupants are handicapped, the travel distances have been reduced to 10 and 20 m for unidirectional and multidirectional escape routes respectively.

Another problem considered by the regulations is the confinement of occupants in wheel chairs or beds. This requires the width of doors and other exits to be increased to 910 and 1500 mm respectively to allow their free passage. The lack of mobility also influences the speed with which the occupants can evacuate or be be evacuated. For this reason the need for horizontal evacuation in the first stage has been recognised where any floor has more than 40 beds. Compartmentation has to be provided so that occupants from either side can be moved from the area at risk relatively quickly.

Training of staff for the evacuation of occupants and fire control are additional factors which the management can be required to undertake. Contents of such buildings should be also examined for their ease of ignition and smoke producing properties. The regulations make no precise recommendations in this connection but the management in discussion with the fire authorities should provide furniture and fittings which are resistant to ignition from small sources.

Type 5 - Hotels

All buildings in this category have provision for sleeping accommodation and are frequented by people unfamiliar with the precise layout. For this reason the regulations have specified the use of protected corridors or lobbies to connect the bedrooms to the storey exit. The permissible travel distances are reduced in regulation 8.5.2 particularly for buildings accommodating handicapped persons.

Fire detection is also considered essential for this type of occupancy and has been specified if accommodation is provided for more than 10 occupants. In addition to early detection occupants need to have clear indication of the safe routes to take. The requirements specify the provision of warning and mandatory signs as well as escape lighting. The signs have to be carefully installed and plans provided in rooms and corridors to show the available escape routes. Hotel occupants need to be informed on their arrival the location of escape stairways. Too often in fires occupants seem unaware of the provision of escape facilities.

The regulations have identified kitchens as a potential fire area and these are required to be enclosed in fire resisting construction.

Occasionally hotels are part of a building complex with the lower parts being used as offices or shops. Complete separation of various usages is essential, lifts and stairways should be isolated on the same basis as for Type 3 buildings.

Where the lower part of a hotel is used as a public assembly area with bars, restaurants, meeting rooms etc, complete compartmentation is not always possible, such areas are permitted to have open stairways, escalators etc provided these are confined to two storeys only.

Type 6 - Schools

Schools and other educational buildings do not, in general, require any additional precautions. The nature of the occupancy and the presence of supervisory staff means that such buildings have usually a good safety record in fires. A single stairway is acceptable in 2 storey buildings where not more than 120 people are likely to be present. However multi-storey buildings should be provided with escape lighting in corridors, lobbies, stairways, etc. Consideration should be given to the safe use of materials - eg laboratories where experiments using heat, electricity or chemicals are performed.

Type 7 - Offices

The occupants of offices should be familiar with their surroundings and aware of the location of all escape routes and other facilities. For small buildings consisting of not more than two floors, one of which may be a basement, one unprotected stairway is acceptable under regulation 8.7.1 (fig 8.9). For two storey high office buildings with a basement, a separate, protected stairway from the basement must be provided if the upper two storeys have an unprotected stairway (fig 8.10). In any case the unprotected stairways must discharge close to the exit door, at a distance of 3 m or less. Escape over roofs of office buildings is permissible provided an alternative internal route is available. Roof routes must be clearly marked and must not be exposed to attack from a fire.

Often offices in a building are in different tenancies, the regulations require that escape facilities for each tenancy should be separate and not pass through each other's areas and common use corridors should be of a protected type. The need for a fire detection system exists in such cases and all the occupants in a floor need to be made aware of the occurrence of a fire. The management should consider regular fire drills in multi-occupancy buildings.

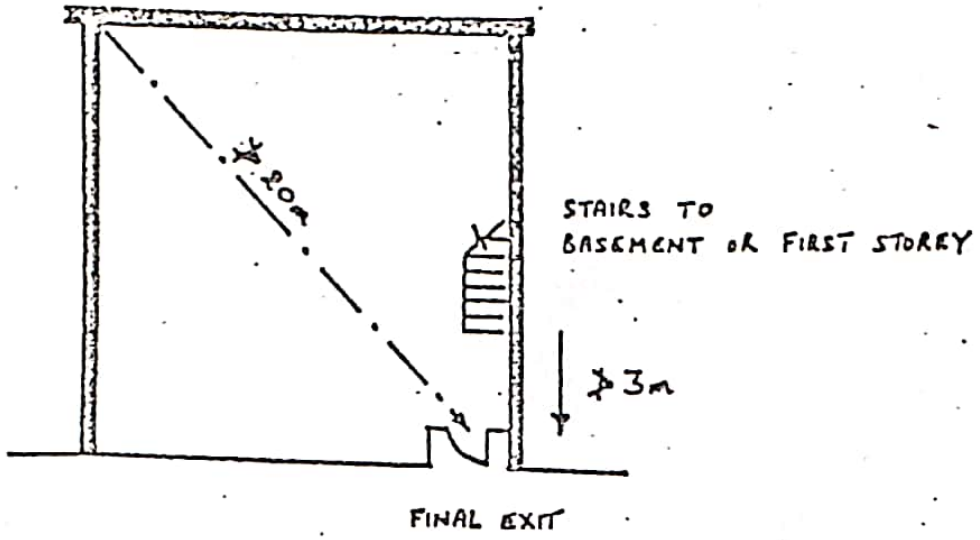


Figure 8.9 Small building types 7 and 8 (2 storey)

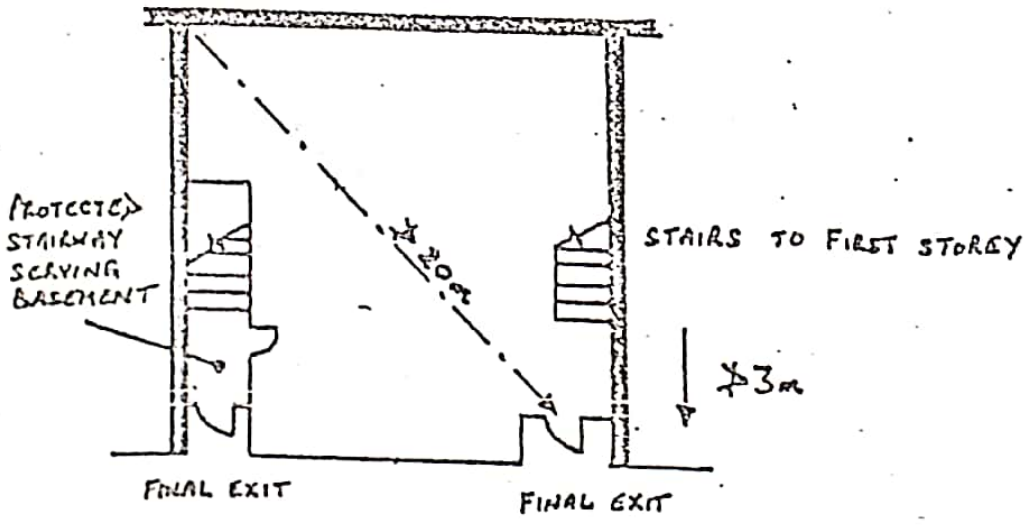


Figure 8.10 Small building types 7 and 8 (3 storey)

Type 8 - Shops

This category includes not only shops and department stores but also restaurants, cafes and bars. Large shopping complexes where numerous different businesses are carried out under one roof are dealt with in Chapter 9.

Fire safety problems posed by small shops are not serious, hence the regulations permit buildings up to two storeys to have a single escape route provided the travel distances are not excessive. Single storey shops which do not deal with highly flammable materials, and restaurants and bars with a capacity of less than 100 and travel distances less than 30 m have a similar concession on the number of escape routes. Buildings on two floors, which may include a basement, are permitted to have unprotected stairways provided the discharge point is not more than 3 m from the exit door (fig 8.9). The same rule is applied to two storey buildings with a basement provided the basement has a separate protected stairway (fig 8.10). Stairways serving small basement or first floor restaurants or bars with accommodation for 30 persons or less may be unenclosed at the restaurant or bar level.

Restaurants, cafes and bars are prone to fires by carelessly discarded cigarette ends and it is therefore proposed that the seating should not be of an easily ignitable type and be able to resist smouldering. Furthermore contact between a seat and a combustible wall lining should be prevented by the provision of a gangway.

Kitchens, excluding small cooking areas, need to be enclosed in fire resisting construction.

Escape lighting is required in shops other than in small ground floor sales areas not exceeding 280 m^2 and in naturally lit stairways in buildings up to three storeys with similarly small sales areas.

Large department stores are specially vulnerable to rapid fire spread and regulations require all buildings above 7000 m^3 in volume to have an automatic sprinkler system.

Type 9 - Assembly buildings

Assembly buildings cover a variety of uses from museums and sports stadia to cinemas and dance halls. The number of occupants can vary from a score to a few thousand, and conditions can range from open air to basement discos. It is in buildings of such type that many people can be at risk and that adequate means of escape design is essential.

The regulations in 8.9 have stressed strongly the provision of escape routes and ensuring that in an emergency the occupants can get out of the building. In the case of small buildings, having an occupancy loading not exceeding 100 and a floor area not exceeding 165 m^2 one exit is acceptable as is from individual rooms where not more than 30 people are likely to be present. For other cases, tables 8.5 and 8.6 of the regulations relate the size and the number of the exits to the number of occupants present.

The regulations also require provisions to be made for the safety of the performers and staff in buildings having staged performances (regulation 8.9.2) and the use of low flammability materials for scenery and other property (regulation 8.9.15). Audiences using seated accommodation can have serious escape problems, if the gangways between seats are not adequate and if there is a tendency for the seating to collapse. The regulations require the seats to be fixed to the floor (regulation 8.9.8) or to be secured together in lengths of four or more. The presence of tiers also hinders rapid movement and safety provisions have been made for adequate gangways as well as barriers at the front of high level seating (fig 8.11).

The nature of the seating is also controlled and is required to be resistant to ignition and smouldering. The requirements for low flammability also apply to the construction of stands in exhibition halls.

The regulations also stress the importance of ensuring that exits and escape routes are so located that they do not lead to congestion by requiring them to be uniformly distributed, well protected and without dead-ends. Common discharge areas are also discouraged (regulation 8.9.5).

Escape lighting is essential except for ground floor areas having less than 100 occupants. Escape stairways need protected lobbies. These lobbies are specified for escape stairways serving upper floors and basement, for corridors connecting dressing rooms and the stage, between a stage and an exit and between projection rooms and areas frequented by the public.

Ventilation over the stage area separated by a safety curtain from the auditorium should consist of a fusible link operated lantern light and a quick release for the safety curtain so that a fire on the stage is prevented from entering the autitorium. Areas used for the storage of scenery also require ventilation arrangements.

If panic bolts are provided on exit doors from an auditorium or another part of a theatre or assembly room these should be in an unlocked condition when an audience is present and should be of a design which is easy to operate to prevent a panic situation.

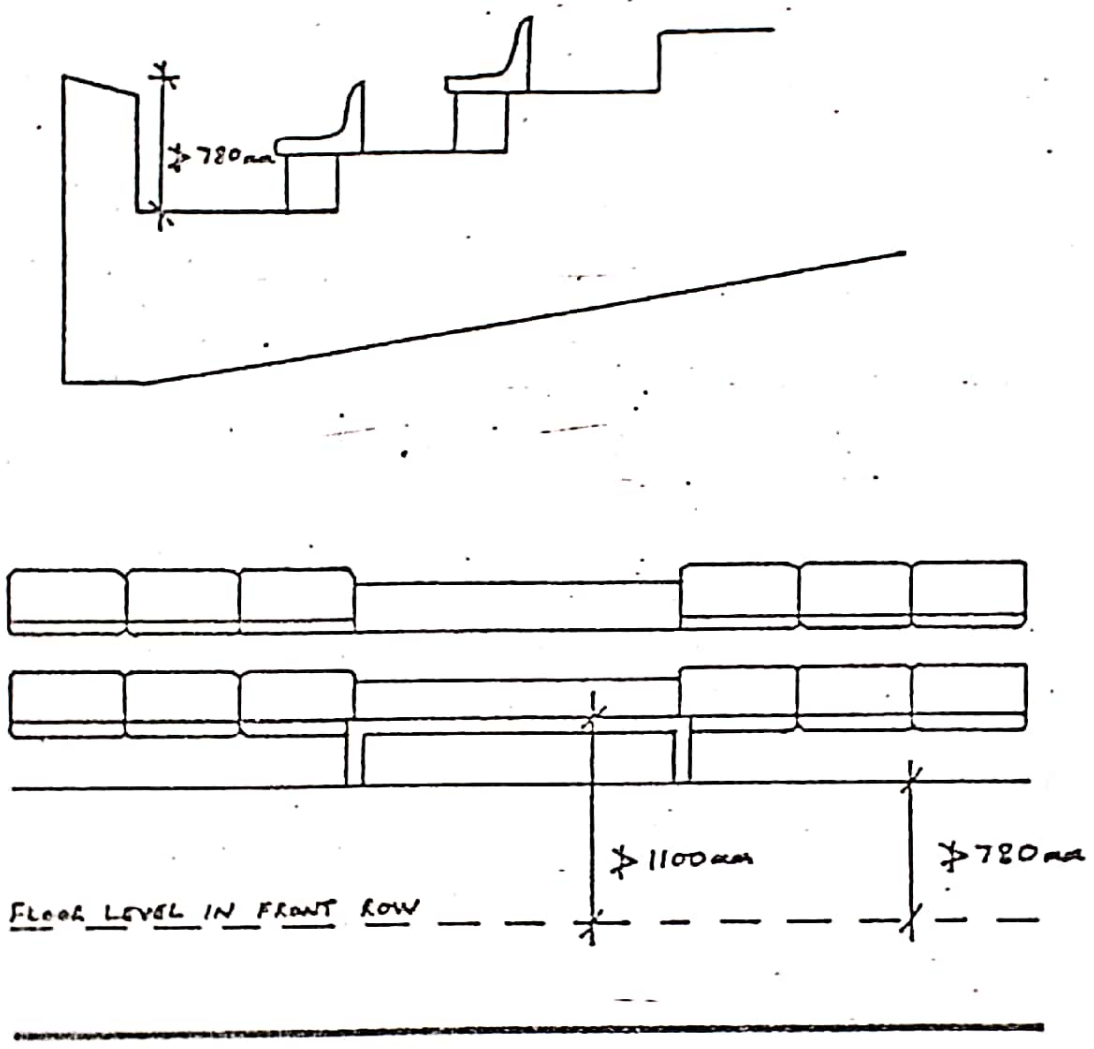


Figure 8.11 Protection to balconies in type 9 buildings

Type 10 - Single storey industrial

Such buildings are expected to present less hazard to the occupants than multi-storey buildings but the nature of the operations needs to be taken into account. For this reason the regulations classify the buildings into three categories; low fire risk buildings are those where heavy engineering or 'wet' operations are carried out and combustible materials are minimal eg foundries, cement works, brick making etc.

Normal fire risk buildings are those which do not qualify for the other types eg motor car factories, refrigerator manufacture, repair shops etc.

High fire risk buildings contain quantities of combustible material and deal with the manufacture and fabrication of products which can burn easily and create smoke problems eg chemical manufacture, polymeric and rubber products, food processing, dairy products etc.

The distinction of fire risk allows the travel distances to be adjusted, with the normal fire risk buildings having the common requirement of 20 m for unidirectional and 40 m for multi-directional travel. The values are halved for high fire risk buildings and increased by 50 per cent for low risk buildings. The travel distances for low and normal risk buildings can be increased such that exits are up to 60 m apart provided they are clearly signposted. If the building exceeds 7000 m^3 the provision of automatic sprinkler installations is obligatory.

Type 11 - Multi-storey industrial

The regulations allow some concession on the number of escape stairways for low and normal fire risk occupancies provided the permissible travel distances given in the previous section and table 6.1 of the regulations are not

exceeded and the building height is limited to three storeys for low, and two storeys for normal, fire risk occupancies. Further relaxations are possible when protected stairways are used, and escape routes are clearly marked, for the two grades of occupancies the exits can be 60 m apart. However if a factory building is divided into a number of tenancies, then each must have routes leading to the storey exits without passing through another tenancy.

Industrial buildings often have office accommodation, in a small organization it may consist of one or two rooms in one corner of the factory. In such cases the travel distances for the staff have to be considered. In larger establishments the offices may be separate on one side of the factory building, these should be treated as type 7 occupancy and compartmented from the industrial part of the building.

Stores in industrial buildings require special consideration; flammable liquids should be separately stored in well protected buildings, with restriction on admittance and smoking. If large quantities have to be kept, the stores should be separate compartmented buildings and treated as types 13 or 14 as appropriate.

Automatic sprinkler installations are required in buildings having a volume greater than 7000 m^3.

Type 12 - Car parks

Car parks can be special separate buildings or the lower part of a commercial or residential building often including one or more basement levels. The number of occupants in a car park is usually not large and the main fire problem is due to malfunctioning of an automobile or a van.

The regulations accept a single escape route for car parks at one floor, first storey, ground floor or basement, provided the travel distances are acceptable. In such buildings regulations also accept the use of ramps as one of the escape routes, not if it is the only escape route, provided the occupants will be protected from direct flame effects by the provision of fire resisting side walls (fig 8.12). Ramps may also be provided for escape purposes in split level parks provided the stated travel distances are not exceeded (fig 8.13). All escape stairways are required to be located against an outside wall and provided with fire resisting doors.

The importance of ventilation to reduce fume concentration is recognized by the regulations and ventilation facilities may consist of openings in walls for above ground car parks to give cross ventilation or there must be a separate mechanical system. Any mechanical system must consist of two separate parts each capable of functioning independently. In some cases where adequate natural ventilation exists the car park may be classified as open sided and the authorities can consider further relaxation on fire resistance requirements to half the values shown in table 7.7 of the regulations. The regulations do not give positive guidance on this but some technical publications are available from other countries.

Car parks exceeding 500 m^2 in floor area are required to be provided with automatic sprinkler systems.

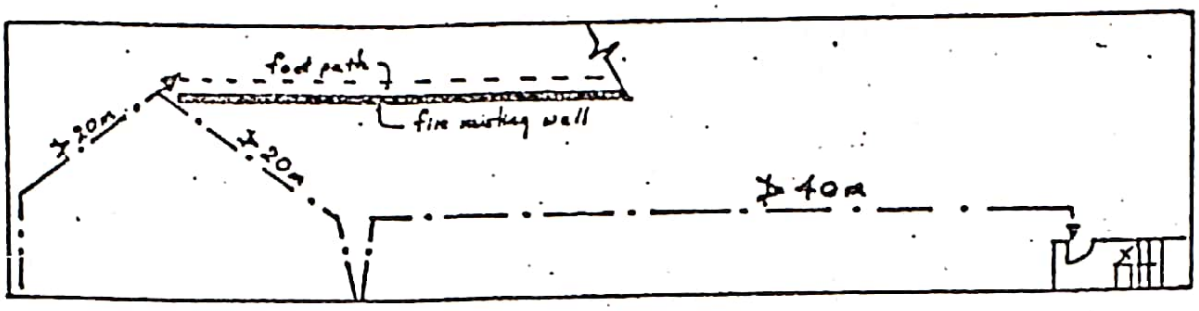


Figure 8.12 Basement or first floor level car park

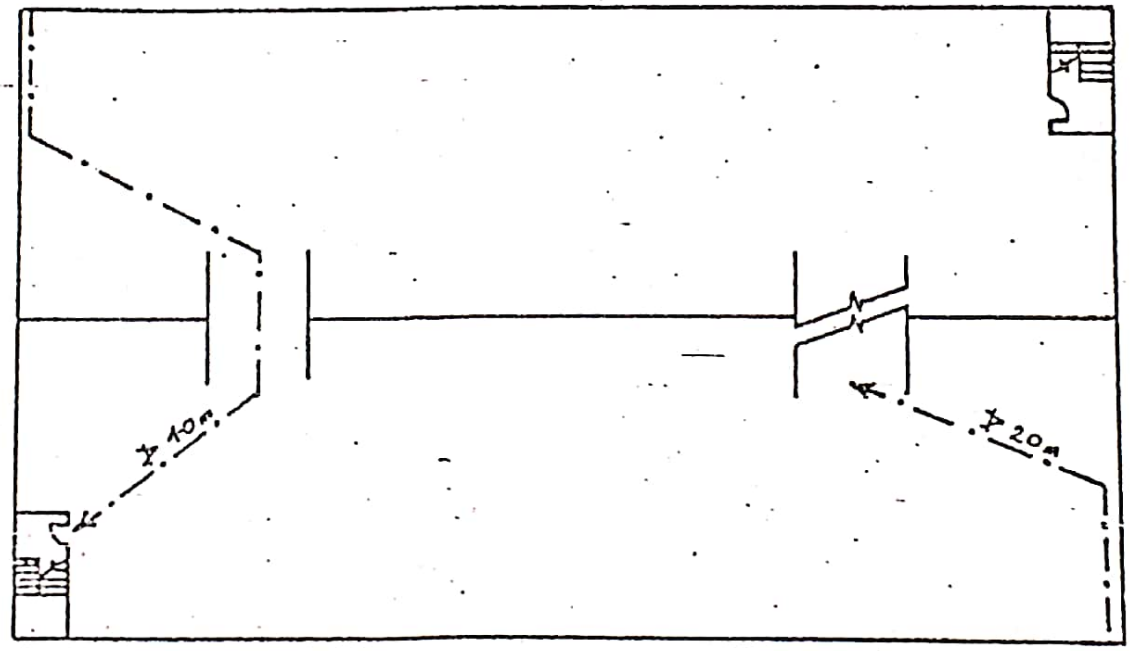


Figure 8.13 Split level car parking

Type 13 - Storage (low fire load)

Storage buildings have been split into low and high fire load categories on the basis of the fire load and for low fire load buildings the main concern is to keep a fire under control before the fire brigade arrive on the scene. For this purpose the provision of an automatic sprinkler system has been specified where the fire load exceeds 1000 MJ/m^2 of the floor area and the building size is in excess of 10,000 m^3.

Type 14 - Storage (high fire load)

The limit at which automatic sprinkler protection has to be provided has been reduced to 3000 m^3 for high fire load storage buildings. Such buildings will often have high rack storage systems. These present a special fire control problem and the design of the automatic sprinkler system needs to be suitable. The advice of the fire authorities should be obtained and the technical literature studied to obtain the most effective system for the purpose.

CHAPTER 9

BASEMENTS, HIGH RISE BUILDINGS AND SHOPPING COMPLEXES

General

This chapter is complementrary to Chapter 8 and specifies special requirements for basement areas, high rise buildings and shopping complexes. Each of these has been treated separately because of special needs for occupant safety and fire control. None of these is a building type as such; any of the building types dealt with in Chapter 8 can have a basement, can be high rise ie more than 8 storeys in height or having floors higher than 20 m above ground level (exceptions types 1, 2 and 10), and shopping complexes are a special category of type 8 buildings. The definition for high rise building is subject to further discussion. It is often associated with the height of building, defined either as height of the external wall with a flat roof construction or to half the height of of a sloping roof. This is intrinsically wrong as the important dimension is the height at which occupants are likely to be present, hence the concept of the height of the topmost floor has been proposed. This can be expressed as a distance or the number of storeys. The height is related to the facilities possessed by the fire brigade to rescue occupants and to fight a fire from the outside. If it feels capable of dealing with a height greater than 20 m, this can be substituted.

Basements

In general the basements should have more than one escape route and the basement stairways should be kept separate. The regulations however allow concessions; when the occupancy loading is not more

than 50 a single escape route is acceptable and when the building has more than one escape stairway all but one of these may go directly to the basement area. However if any stairway serves the basement is should be approached by a ventilated protected lobby. Smoke clearance from basements is a critical factor and special requirements are given in regulation 7.5.10 for this purpose. These specify high level smoke outlets with openings aggregating to 2.5 per cent of the floor area. Often these have to be opened by the fire brigade when they arrive on the fire scene. A mechanical smoke clearance system can be used as an alternative.

Escape lighting is also essential in the escape routes. If the basement is on sloping ground and used for car parking it is possible that some daylight may be available but this has to be at least 30 per cent in the shape of openings in the wall.

The fire resistance and compartmentation requirements are more stringent for basements than for the first storey of a building. This is a reflection of the difficulty of controlling a basement fire. The fire brigade need all the information they can concerning a basement and plans should be prepared for their use to enable them to find their way in and out of basements.

High rise buildings

The standards of construction and protection are higher for such buildings owing to the large number of occupants who may be at risk and the difficulties likely to be experienced in controlling fires in such buildings.

The external enclosure is required to be Class A and internal linings Class A in escape stairways and Class B elsewhere. The stairway widths have to be increased to deal with the larger number of people likely to be present and data are given in Tables 9.1 and 9.2 of the regulations. Every escape stairway must have a protected lobby or a protected corridor approach and escape lighting should be provided. If a building contains parts at a height lower than 20 m, these parts can be designed for escape purposes according to their size.

The fire resistance requirements for all high rise buildings are 2 hours or more and compartmentation has to be provided such that each floor is a compartment floor, in order to minimise the danger of fire spread. All internal partitions should play some part in reducing fire spread and need to have fire resistance of 30 minutes or be made of noncombustible materials.

Need exists to prevent vertical fire spread from flames emitted from windows. Serious fire spread has resulted through this route. The regulations make a number of provisions to reduce the probability of spread by requiring fire resisting vertical or horizontal separation between windows at different floor levels (fig 9.1). A 1 m separation has been recommended.

Facilities for fire control need to be provided: hosereels for initial attack as well as fire hydrants and rising mains. Automatic sprinkler installations are also specified except for type 3 buildings and bedrooms in type 5 buildings. The fire brigade will usually arrive on

the scene with quite a few appliances hence access for fire brigade appliances must be adequate and internally at least one escape stairway should be constructed so that it can be used by the fire brigade. It needs to be provided with a lobby approach (fig 9.2). The fire brigade should also be able to use one or more lifts which should have special manual control facilities.

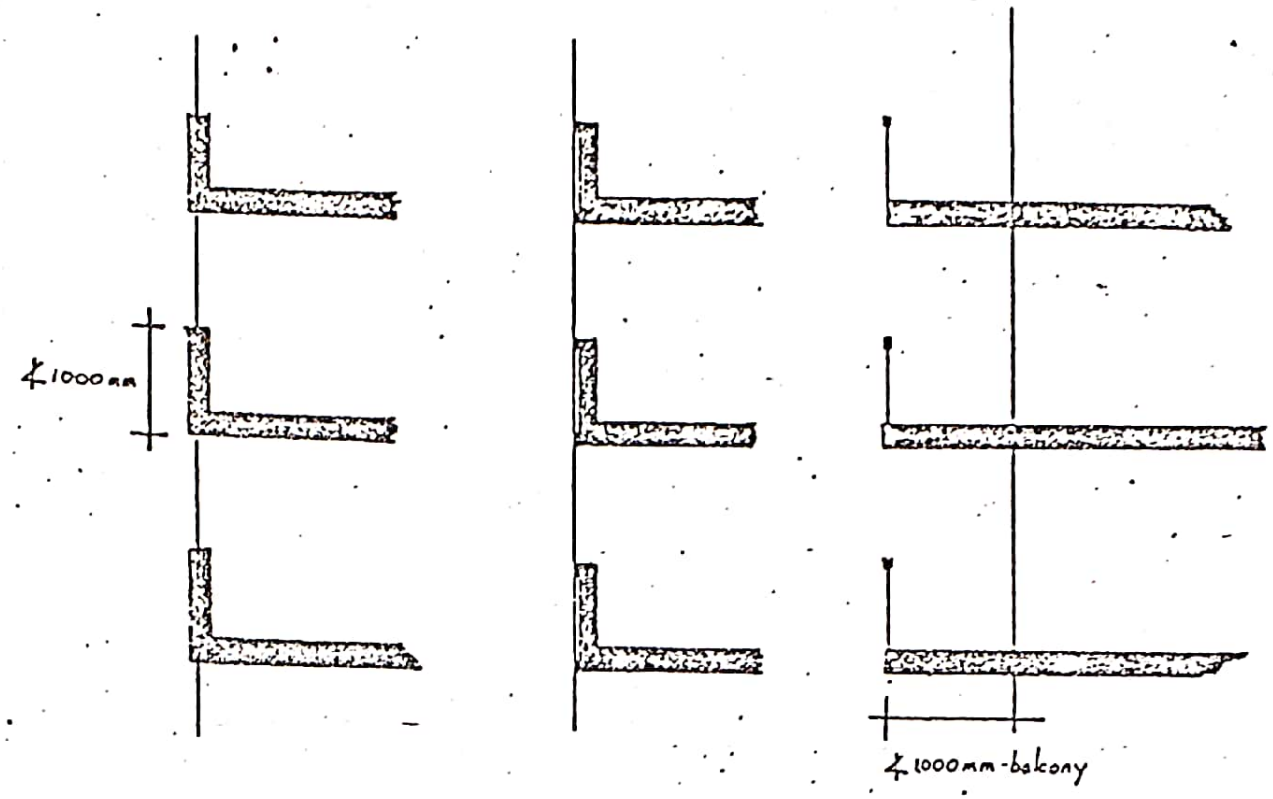


Figure 9.1 Protection against vertical external fire spread

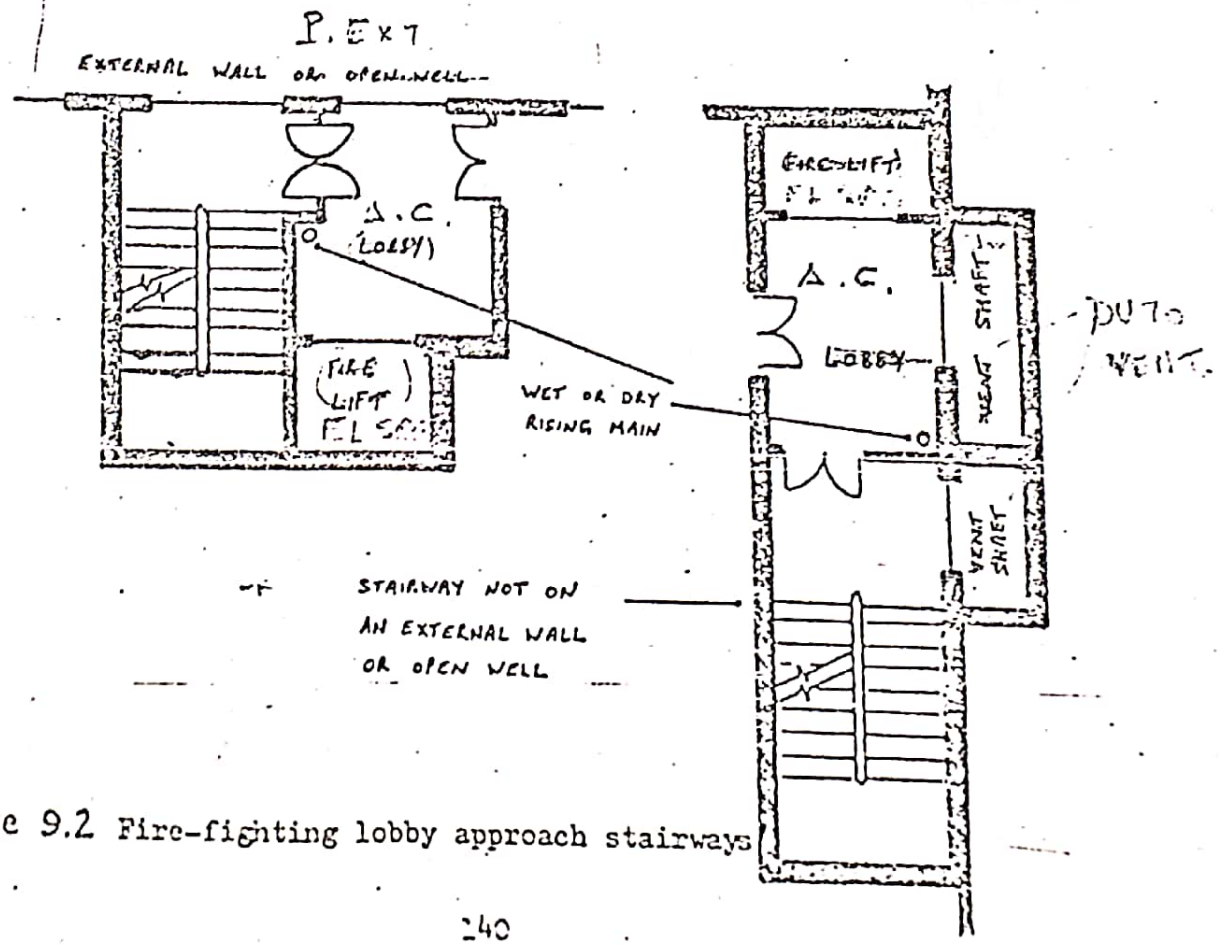


Figure 9.2 Fire-fighting lobby approach stairways

Shopping complexes

Regulations have considered two main problems with shopping complexes, the large number of occupants that may be present and therefore the need for adequate and effective means of escape, and problems created by smoke in such occupancies. A shopping complex can include a range of shops and services and combine under one roof facilities covered by a number of building types eg types 5, 8, 9 and 12. Each must conform to the requirements given in Chapter 8. If a shopping mall is not covered, ie it is more like an open market the smoke problem is less severe as it can escape easily to the outside. Multi-storey covered shopping malls, with criss-cross stairs and escalators have more serious escape problems.

In addition to satisfying the means of escape provisions in Chapters 6 and 8, exit from each unit must be in two directions for covered malls, and travel distances must comply with table 9.3 which limits the maximum spacing of exits to 90 m. The size of escape routes and exits must be adequate for the number of occupants expected to use them.

Smoke control in shopping malls is a complex problem and requires the provision of smoke reservoirs, extraction facilities and provision for fresh air to replace the smoky atmosphere.

Fire detection and warning systems need to be extensively used with a provision for public address system to guide the occupants. The system should be under the control of a single central management and available to the fire brigade when they arrive. Escape lighting is essential and fire exit and route signs must be carefully installed so that they are prominent and cannot be confused with numerous other signs

which exist in shopping complexes. If necessary the management should prohibit the installation of other signs in the vicinity of escape signs.

Each unit must be constructed as a fire compartment, consisting of non-combustible fire resisting boundaries with fire resistance appropriate for the nature of the occupancy, with further compartmentation as required by regulation 7.11.

Sprinkler installations are required if the total floor area exceeds 3000 m^2 and such installations must be carefully designed to allow for varying heights and shapes of the shopping complexes.

Fire brigades need to have an easy access to the complex and enter into the building from exits not more than 90 m apart.

Car parks surrounding complexes can be a special problem and enough barriers must be provided to permit fire appliances to get close to the building. The fire authorities must be in possession of plans of such buildings with all access points and fire facilities clearly marked.

CHAPTER 10

FIRE SAFETY ASSESSMENT

The fire protection measures and their application to various buildings as described in Chapters 5 to 9 of the regulations are based on well recognized approaches developed in a number of countries. Certain assumptions are made about the fire growth and severity and requirements developed to deal with different safety aspects. However, most of the requirements are individually conceived and applied in isolation from each other. A fire occurrence is a complex phenomenon in which different factors inter-act with each other and in the same way the fire protection measures act together in their response to the fire situation. This interaction and inter-linking of measures has not been given full recognition except in a few concessions allowed when sprinklers are used.

The most satisfactory way in which this may be done is by adopting an overall systems approach to fire safety, in which quantitative assessments are made on the one hand of the hazard that is present and on the other of the safety needs for the building. The two are equated taking into account the presence of various active fire protection measures. Figure 10.1 shows a simple concept which may be employed in evaluating a system for this purpose, and figure 10.2 provides a few more details under each heading.

Fire hazard is due to the burning of contents and materials of construction and is influenced by the constructional features as well as fire control measures that may be present. The presence of sprinklers can reduce the hazard and the availability of the fire brigade can allow an early attack on the fire. The hazard assessment

needs to take into account the consequences of the fire on the occupant safety as well as the damage to property. Fire safety needs are considered from both points of view as well ie occupants and property; however, it is possible that regulations attach more importance to the former. The safety needs are again influenced by the presence of fire protection measures; for example, with a good fire detection system the time available for escape is improved and the probability of occupants reaching a place of safety is increased.

Various techniques are being developed at present and no comprehensive system is available to recommend at present. However, progress has been made in certain areas which can be beneficially pursued by the designers as an alternative to the solutions proposed in the regulations. These solutions need to be discussed with the regulating authorities and it is the responsibility of the designer to provide the supporting evidence. The areas where guidance is available currently are listed below:

1. The regulations have been devised on assuming certain fire loads in buildings but in an actual building the fire load may be different. If it is possible for the designer to evaluate the actual fire load and its rate of burning, it is then possible to estimate the likely fire severity in that building. The consequence of this will be on the fire resistance requirements for the structure. Procedures have been published (reference 1) which allow the calculated rate of burning and the resulting fire severity to be expressed as an equivalent time of fire resistance in place of the requirements given in Chapter 7 of the regulations.

2. Methods are also available to check the fire resistance of structural elements by calculation methods as a substitute for testing or using the deemed to satisfy type of tabulated data. The methods can be applied to elements of concrete, steel and wood and predict the likely behaviour were the element to be subjected to a fire resistance test. Hence the procedures are at present limited to those systems which can be tested. The regulating authorities should be able to accept substantiated proposals from competent experts for this purpose.

3. The fire resistance determination is linked to the testing procedures available for this purpose in various standards. These deal with simple cases of individual elements with many assumptions about loading and support conditions. Often these are not a complete simulation of conditions that exist in a building. The only way in which, at present, a more realistic simulation can be made is by undertaking a special research type investigation in real or purpose built structures. Such efforts need to be encouraged and the regulating authorities should consider the use of such data to deal with special forms of constructions or new methods of using materials. The data should be analysed by a competent fire engineer to demonstrate its validity and capability to provide the required level of safety.

4. Methods are also under development to predict smoke movement in certain types of buildings, eg shopping malls (reference 2). These techniques allow smoke clearance systems to be designed for the layout used in a given shopping mall. As these complexes differ greatly from each other no single solutions would be appropriate for all. The regulating authorities should consider systems based on these methods as appropriate for achieving the safety objectives.

5. The regulations have given some relaxation or concessions where sprinkler systems are installed. This is a simple approach until more precise data become available on the effect of sprinkler installations on the rate of growth of a fire and its final severity. Experimentation and research is in progress at present on this topic and the regulating authorities should be able to consider such work as a basis for relaxation of some of the specified requirements.

There are many other areas of fire safety in which developments are taking place at present. It is not possible to state at this time what account should be taken in considering the requirements in a building. However, many of these require specialist knowledge available only to a limited number of expert fire engineers. It would be in the interests of the regulating authorities, designers and the users to consider giving official recognition to such experts on the basis of their competency. At present no formal qualifications can be considered for this purpose as is the case with architects, structural engineers etc but the regulatory authorities on the basis of their own judgement could prepare a register of such people so that their expertise can be duly recognized.

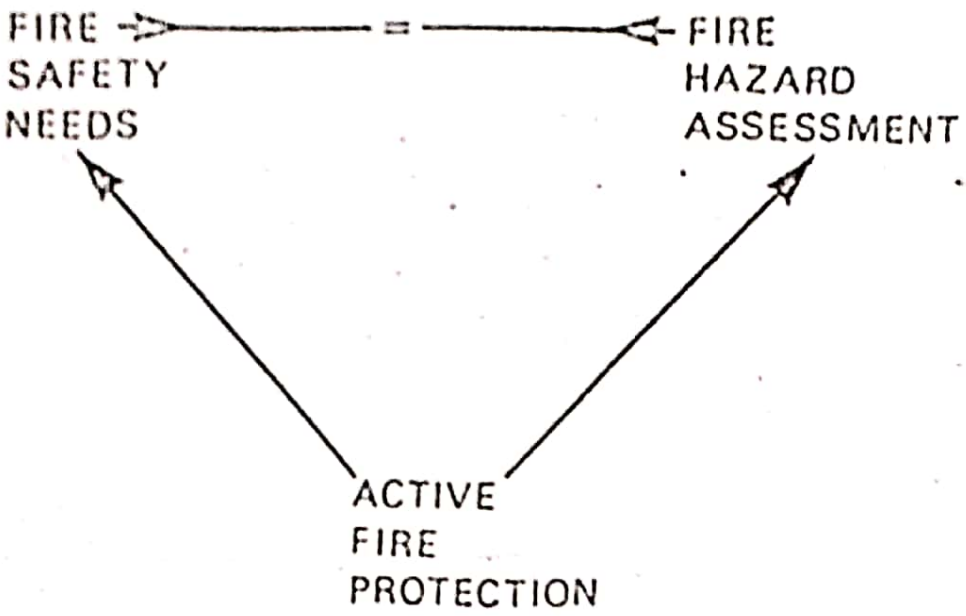


Figure 10.1 Fire hazard in relation to fire safety

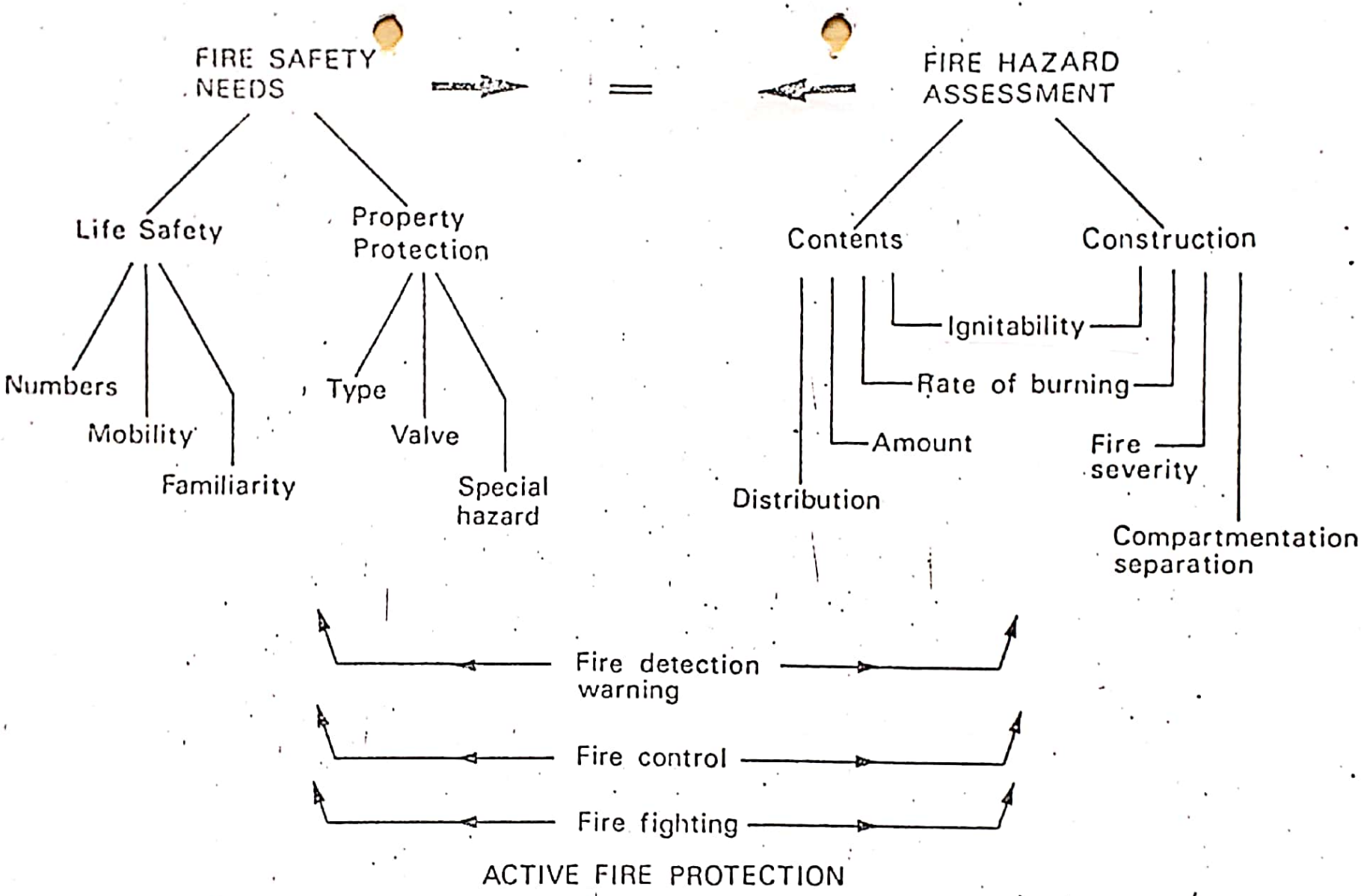


Figure 10.2 Interactions among fire safety, fire hazard and fire protection

CHAPTER 11

FIRE SAFETY MANAGEMENT

The provisions given in the regulations, in Chapters 6 to 9, deal primarily with matters concerned with the layout and construction of the building as well as the provision of facilities to detect and extinguish the fire. These measures have the effect of reducing harm to the occupants and damage to the structure. Fire safety has other aspects to consider as well, the most prominent of which can be referred to under the general heading of human factors. Building occupants are often responsible, through carelessness, of creating conditions which start a fire eg throwing of matches and cigarette ends. Their reaction can also affect seriously the evacuation of occupants and even with adequate conditions for escape, panic can lead to disaster. The problems are accentuated when dealing with buildings containing a large number of people at one time.

In the interests of safety it is therefore important that the management of buildings with large occupancy levels or special problems take an active interest in fire safety matters and put into operation additional measures which go beyond literal compliance with the regulations. Buildings where such measures are advisable are high rise offices (type 7), department stores (type 8), assembly buildings (type 9) with music and dancing facilities, and large industrial (type 11) buildings.

In the buildings listed above, as well as in many other buildings, the management needs to recognize the possibility of a fire and have plans ready to deal with such an emergency. Work of this type should

not be delegated to a junior member of the staff; senior management should take active interest in fire safety matters. Fire safety can be combined with other safety and security considerations and, depending upon the size of the organization, an organizational structure provided with recognized responsibilities. The main objectives or such a system are,

1. Daily surveillance of the building and facilities to ensure that equipment and operations are conducted safely.

2. To ensure a safe procedure is followed for handling flammable materials.

3. To keep large quantities of flammable goods in safe storage.

4. To check fire control and extinguishing systems eg extinguishers, hosereels, hydrants, sprinklers etc.

5. To have a core of trained staff available to deal with small fires eg by the use of extinguishers, blankets etc.

6. To have an emergency plan in which trained staff can take charge on different floors and in different sections and guide occupants to safety.

7. In large organizations to have trained personnel for fire-fighting and to collaborate with the fire brigade after their arrival on the scene.

8. To prepare guidance documents for the occupants detailing actions to be taken when a fire emergency occurs.

9. To move all the lifts to the ground floor manually or automatically on the occurrence of a fire and to make one or more lifts available to the fire brigade if needed.

10. At the end of each working day to carry out inspection to ensure that no dangerous or unsafe conditions exist after the occupants have left.

Within this broad framework each organization needs to develop a system best suited to its needs in terms of staff facilities and the level of surveillance. In large multi-storey commercial buildings it is possible to combine security and fire safety operations and use electronic detection systems from a central manned operations room. In such a room facilities for controlling lift operations, self-closing hold-open doors, special fire shutters, sprinkler devices, monitoring of signals from detectors, audio warning systems and direct contact with fire brigade can be provided. In a small organization a single person will be able to look after a small shop or school.

Special attention needs to be paid to certain types of buildings because of their use or fluctuating occupancy levels. Hospitals require a 24-hour surveillance by the trained staff, whereas department stores and shopping complexes require special attention at weekends and holidays. Assembly buildings with facilities for music and dancing where a large number of people may be present require adequate trained personnel to prevent panic in an emergency.

If the management has taken an active interest in fire safety matters, it will reduce significantly the possibility of harm to its staff and other occupants and limit the fire damage.

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