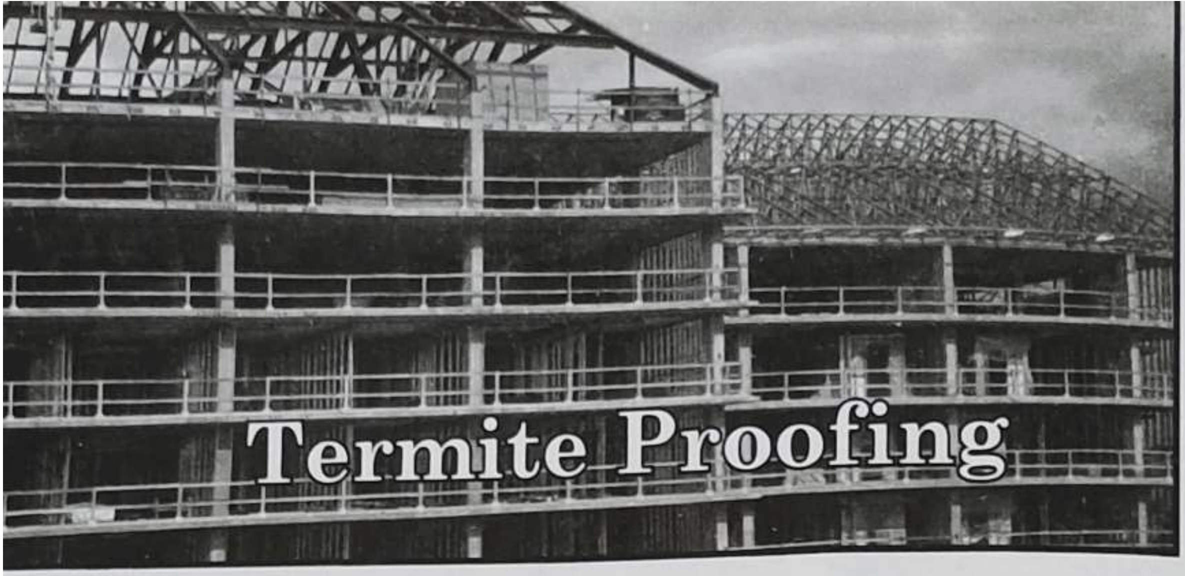

Termite Proofing

CHAPTER 22

22.1 INTRODUCTION: TYPES OF TERMITES

Termites, popularly known as white ants cause considerable damage to wood work, furnishings etc., of buildings. In some countries, the loss caused due to termites is estimated to be as high as 10% of the capital outlay of the buildings. *Anti-termite treatment* is, therefore, necessary so that damages are either reduced or stopped all together.

Termites are of two types:

1. Dry wood termites 2. Subterranean termites.

1. Dry wood termites: These termites live in dry wood in small colonies, without maintaining any connection with the soil. They are generally found in humid coastal areas. In India, they are found on coastal regions of South India, though their number is low. They travel and work through wooden structures only.

2. Subterranean termites: These termites have their main colonies in soil, under ground. They cannot survive without maintaining any connection with their prime colonies in the soil. However, they travel in search of food, mostly wood and cellulose matter, through shelter tubes or galleries or tunnels in other materials. These tubes are coated with soil all round. As they consume wood, secondary colonies are developed there. These termites require moisture for their existence. These termites enter the buildings through foundations or from ground adjacent to the buildings and advance upward through floors destroying everything that comes within their reach. They also travel through cracks and crevices in masonry and joints and cracks in floors.

In northern India, the most important species are those belonging to the group of subterranean termites which live in extensive colonies in the ground. Sometimes they build their nests near ground in stumps of dead trees or create colonies in the form of dome-shaped mound on the ground. They require both moisture as well as darkness for their survival. These termites have five *caste s* : (*i*) Queen, (*ii*) King, (*iii*) Soldiers, (*iv*) Sexual winged male and female adults, and (*v*) Workers. Their *workers* forage over extensive areas for edibles, maintaining direct connection with the colony which depends on soil moisture for survival.

A careful examination of untreated building will show that damage by termites and evidence of their activity is not difficult to find. Often such damage or termite activity can be found on the upper floors as well. Even if termite damage on the lower floors is not clearly visible, this should not be lead to the erroneous conclusion that they have not established a colony on the upper floors.

22.2 ANTI-TERMITE TREATMENT

Anti-termite treatment is divided into two categories:

(*a*) **Pre-construction treatment**

This treatment is started right at the initial stage of construction of building. Pre-construction treatment can be divided into three operations:

(*i*) Site preparation.

(*ii*) Soil treatment.

(*iii*) Physical structural barriers.

(*b*) **Post-construction treatment**

The treatment are discussed in the following headings:

22.2.1 Site Preparation

This operation consists of removal of stumps, roots, logs, waste wood and other fibrous matter from the soil at the construction site. This is essential since the termites thrive of these materials. If termite mounds are detected, these should be destructed by use of insecticide solution, consisting of any one of the following chemicals :

Chemical	*Concentration by weight*
(*i*) DDT	5%
(*ii*) BHC	0.5%
(*iii*) Aldrin	0.25%
(*iv*) Heptachlor	0.25%
(*v*) Chlordane	0.5%

Four litres of the above emulsion in water is required per cubic metre of volume of mound. Holes are made in the mound at several places by use of crow-bar and the insecticide emulsion is poured in these holes.

22.2.2 Soil Treatment

The best and only reliable method to protect building against termites is to apply a chemical treatment to the soil at the time of construction of the building. This should be done in such a way that a complete chemical barrier is created between the ground from where the termites come and damage the wood work in the building. An insecticide solution consists of *any one* of the following chemicals in water emulsion:

Chemical	*Concentration by weight*
(*i*) Aldrin	0.5%
(*ii*) Heptachlor	0.5%
(*iii*) Chlordane	1%

Out of the above chemicals and several other chemicals, *Aldrex* 30 E.C. has proved to be the most effective. It has the following advantages:

(*i*) It is highly toxic to termites.

(*ii*) It can easily be applied after dilution with water.

(*iii*) It is insoluble in water. In other words, this chemical will not dissolve in subsoil water and disappear quickly from the site.

(*iv*) It is effective even many years after application.

One part of '*Aldrex*' 30 E.C. is diluted with 59 parts of water. This provides an emulsion containing 0.5% *aldrin*.

The emulsion should be applied evenly either with a watering cane or sprayer at the following stages:

Stage 1. In foundation pits, to treat the *bottom* and *sides* up to a height of about 30 cm. The emulsion required is at the rate of 5 litres per square metre.

Stage 2. The *refill earth* on both the sides of all built up walls, for width of 30 cm and depth of 45 cm approximately. The emulsion required is at the rate of 5 litres per square metre.

Stage 3. Before laying the floor, the entire levelled surface is to be treated at the rate of 5 litres of emulsion per square metre.

The stages of treatment are shown diagrammatically in Fig. 22.1. When used as recommended above, approximately 200 mL of '*Aldrex*' 30 E.C. would be required to treat one square metre of the covered area.

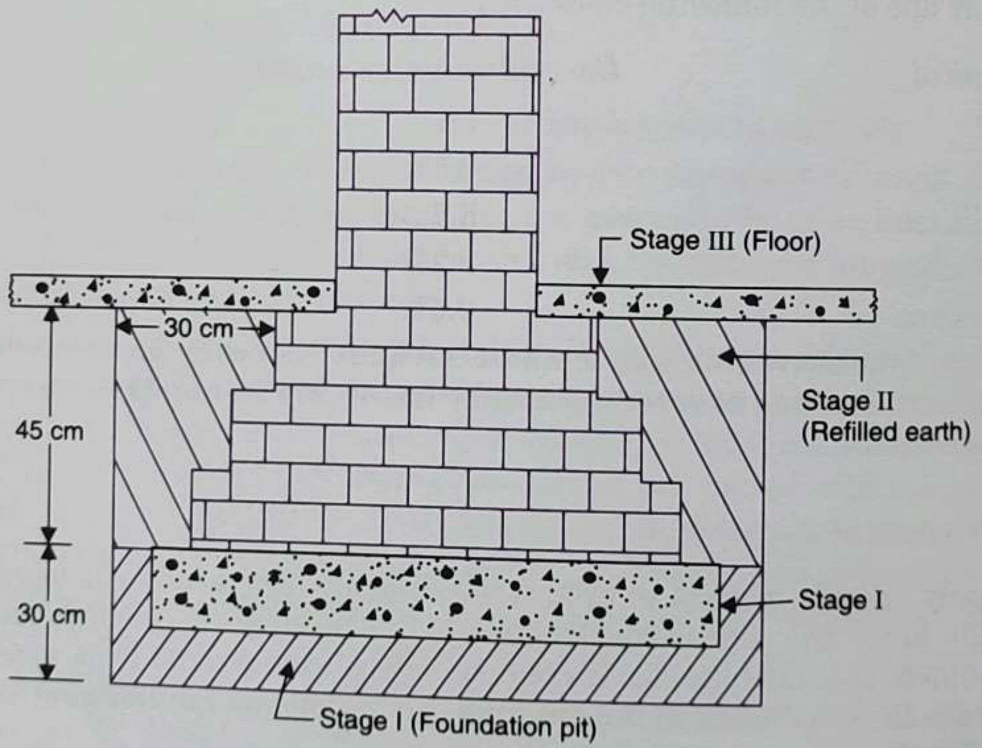

Figure 22.1. Stages of Soil Treatment

22.2.3 Physical Structural Barriers

Continuous impenetrable physical structural barriers may be provided continuously at plinth level to prevent entry to termites through walls. These barriers may be in the form of concrete layer or metal layer. Cement concrete layer may be 5 to 7.5 cm thick. It is preferable to keep the layer projecting about 5 to 7.5 cm internally and externally. Metal barrier may consist of non-corrodible sheets of copper or galvanised iron, of 0.8 mm thick. These sheets are likely to be damaged ; in that case, they become ineffective against termite movement.

22.3 POST-CONSTRUCTION TREATMENT

It is a maintenance treatment for those buildings which are already under attack of termites. As stated earlier, the termites, even after entering the building, maintain their contact with their nest or colony in the ground, through shelter tubes or tunnels lined with soil. This fact is well utilised in the anti-termite treatment. It is essential to carry out inspection to estimate the magnitude of spread of termites in the building, and to detect the points to entry of termites in the building. These points may be in near vicinity of columns, basements, steps leading from ground, bathrooms and lavatories, leaking pipes, drains etc., and the places where wood work is embedded in the ground. In case of multistoreyed buildings, lift wells, casing-coverings of electrical wirings, water supply lines, soil pipe etc., may be the entry points for the termites. Wherever these shelter tubes are detected, these should be destroyed after injecting anti-termite emulsion through these. If the attack is severe, the soil around the building, and soil under the floor may be injected with anti-termite emulsion. This treatment may be applied up to a depth of 30 cm below the ground level. To prevent the entry termites through voids in masonry, 12 mm dia. holes are drilled at 30 cm c/c at downward angle of 45° from both the sides of walls at plinth level and chemical emulsion is pumped into these under pressure. These holes are then sealed. This treatment of drilling punch holes and pumping chemical emulsion is carried out at critical locations such as wall corners, column bases, place of embedment of doors and windows etc. Similar holes are drilled in damaged wood work also and then oil based chemical emulsion is pumped into these.

PROBLEMS

1. Write a note of 'termites and their attack' on buildings.
2. Explain how preconstruction anti-termite treatment is carried out.
3. Explain how post-construction anti-termite treatment is carried out.

CHAPTER 23

Fire Protection

23.1 INTRODUCTION

No building material is perfectly fire proof. Every building contains some materials (such as furniture, clothing, eatables etc.) which can either easily catch fire or which are vulnerable to fire. However, the endeavor of the architects and engineers should be to plan, design and construct the building in such a way that safety of occupants may be ensured to the maximum possible extent in the event of outbreak of fire in the building due to any reason whatsoever. The technical interpretation of *fire safety* of building is to convey the *fire resistance* of buildings *in terms of hours* when subjected to fire is known intensity. It should have structural time interval so that adequate protection to the occupants is afforded. A wider interpretation of fire safety may be deemed to cover the following aspects:

(*a*) Fire prevention and reduction of number of outbreaks of fire,

(*b*) Spread of fire, both internally and externally,

(*c*) Safe exist of any and all occupants in the event of an outbreak of fire,

and (*d*) Fire extinguishing apparatus.

Causes of fire

Most fires are *caused* by carelessness. Common instances of carelessness are: (*i*) careless discarding of lighted ends of cigarettes, cigars, matches and tobacco, (*ii*) smoking in unauthorised places, (*iii*) indifferent maintenance of machinery including overloading and under or over lubricating of bearings, (*iv*) general indifference to cleanliness, (*v*) incorrect storage of materials, (*vi*) faulty workmanship and inattention to electrical installations (this is particularly evident by the fires which occur during the monsoon), (*vii*) un-approved equipment and layout, (*viii*) inattention of persons concerned with inspection and patrol of the premises under their jurisdiction, and (*ix*) inattention of fire safety regulations, etc.

In case of an outbreak of fire, the danger is from fire, smoke and panic. The provision of suitable means of escape should be in relation to these dangers and the number of persons affected. The chances of damage due to panic can be reduced; the *escapes* should be located in such a way that they remain unobstructed by smoke or fumes. The means of escapes from fire should be easily accessible, unobstructed and clearly defined.

23.2 FIRE HAZARDS

Fire safety of buildings should be considered from three aspects and protection should accordingly be provided against the following three types of five hazards.

(a) Possibility of loss or damage to life, referred to as *personal hazard*.

(b) Possibility of fire occurring and spreading inside the building itself, referred to as *'internal hazard'* and

(c) Possibility of fire spreading from an adjoining building or buildings or from across a street or road, referred to as *'exposure hazard'*.

The consideration of *personal hazard* is naturally of permanent importance and requires the provision of liberally designed and safe fire proof exits escapes in all buildings and particularly those having more than one storey.

Internal hazard concerns damage or destruction of the building and influences directly personal hazard. The internal hazard is directly related to *fire load* which, in turn, enables the building to be graded when considered along with the duration of fire.

'Exposure hazard' deals with the risk of fire spreading into a building through the open air from fire in other buildings, from stocks of combustible material etc., or into a division or compartment of a building through the open air from a fire in other division or compartment of the same building.

A small building containing highly inflammable material may constitute a high internal hazard; a large building containing quantities of combustible material, for example, a godown, would also be described as high internal hazard even though the actual outbreaks are likely to be few, because when a fire does occur, the destruction of contents and structural damage might be considerable. Theatres, cinemas and other places of public assembly, even though their combustible contents may be low, are considered to present a high internal hazard primarily because of the large number of people and the extent of personal hazard, involved. On the other hand, from stand point of high combustible content, would constitute low personal hazard because of few people likely to be in such a building.

23.3 FIRE LOAD

Fire load is the amount of heat in kilocalories (kcal) which is liberated per square metre of floor area of any compartment by the combustion of the contents of the building and any combustible part of the building itself. This amount of heat is used as the basis of grading of occupancies.

The fire load is determined by multiplying the weight of all combustible materials by their calorific value, and dividing the floor area under consideration. For example, if a section of a building, having an area of 80 sq. metre has 1200 kg of combustible material having a calorific value of 4000 k cal/kg,

$$\text{Fire load} = \frac{1200 \times 4000}{80} = 60000 \text{ k cal/m}^2$$

Indian Standard (IS: 1641–1988) grades the fire loads into the following three *classes*:

(a) ***Low fire load:*** Not exceeding 275000 kcal/ m^2 and as applying generally to domestic buildings, hotels and offices and similar buildings.

(b) ***Moderate fire load:*** Exceeding 275000 kcal/m^2 but not exceeding 550000 kcal/m^2 applying generally to trading establishment and factories.

(c) *High fire load:* Where the value exceeds 550000 but does not exceed 1100000 k cal/m² applying to fire load grading to godowns and similar structures.

Fire load of any building is classed as of normal or of abnormal fire risk depending on susceptibility of the occupancy of the building to fire. The occupancy of the building may consist of materials in store or manufacturing processes.

Different materials having the same weight and the same calorific value may present different hazards on account of their other properties, such as rate of ignition, speed of burning and liberation of dangerous fumes. Materials also classified for purpose of assessing fire grading under the heading Non-Hazardous (NH), Hazardous (H) and Extra Hazardous (EH) based on the following characteristics: (*i*) explosive tendencies, (*ii*) high inflammability, (*iii*) liability to intensify a fire, (*iv*) generation of intense heat when burning, (*v*) liability to extend the fire zone, (*vi*) difficulty to extinguish, and (*viii*) spontaneous combustion tendencies.

Grading of occupancies by fire load

Based on fire load, occupancies are graded into the following three classes:

1. ***Occupancies of low fire load:*** Under this fall those occupancies whose the fire load does not exceed an average of 275000 k cal/m² of net floor area of any compartment, nor an average of 550000 k cal/ m² on limited isolated areas. Domestic buildings, hotels, boarding houses, restaurants, schools, hospitals, temples, mosques, commercial offices come under this category. Also, the factories and workshops in which materials and processes are of a recognised non-hazardous nature (such as an engineering workshop) come under this.

2. ***Occupancies of moderate fire load:*** Under this fall those occupancies whose the fire load exceeds an average of 275000 kcal/m² of net floor area of any compartment but does not exceed an average of 550000 k cal/m² nor on average of 1100000 kcal/m² on limited isolated areas. Examples of occupancies that fall under this category are retail shops, emporium, bazaars, factories and workshops generally.

3. ***Occupancies of high fire load:*** Under this fall those occupancies whose fire load exceeds an average of 550000 kcal/m² of net floor area of any compartment but does not exceed an average of 1100000 k cal/m² of net floor area, nor an average of 2200000 k cal/m² on limited isolated areas. Examples of occupancies that fall under this category are godowns and similar buildings used for bulk storage of non-hazardous materials and goods.

23.4 GRADING OF STRUCTURAL ELEMENTS

Structural elements of buildings are graded, for fire resistance, by the time for which they resist a standard fire of given time temperature grading. The time-temperature grading is based on observations in actual fires. The relationship between the actual fire expressed as fire load and the standard fire is established by burning down weights of combustible material corresponding to different classes of fire loads, so as to match the time temperature grading of the standard fire. From the results it follows that the different grades of fire resisting structural elements will resist the corresponding fire loads shown against them in Table 23.1 (IS : 1641–1988).

Thus, a structural element classified as of grade 4 will successfully withstand the standard fire severity and comply with other conditions for an hour. If that structural element is incorporated in a building of which the fire load gives rise to a fire, equivalent in severity to one hour severity in the test, then the structural element should resist the building fire without failure.

Table 23.1. Classification of Structural Elements

Grade No.	*Time in hours (min. resistance against standard fire)*	*Fire load and class of fire which the structural element can withstand*	
		Fire load in k cal/m²	*Class of fire*
1	6	1100000 and over	Very high
2	4	500000 to 1100000	High
3	2	275000 to 500000	Medium
4	1	Less than 275000	Low
5	$\frac{1}{2}$	—	Very low

23.5 GRADING OF BUILDINGS ACCORDING TO FIRE RESISTANCE

Structural precautions aid in giving a building the necessary resistance to a complete burn and restrict any spread of fire and also minimize the personal hazard. In grading building according to fire resistance and structural precautions provided, it has been assumed that no assistance will be forthcoming from municipal fire brigade and that no fire fighting apparatus has been provided or attached to building. National Building Code of India (SP: 7–2005) divides buildings into the following *four* types according to the *fire load* the building is designed to resist:

(*i*) *Type 1 construction.* All structural components have 4-hours fire resistance.

(*ii*) *Type 2 construction.* All structural components have 3-hours fire resistance.

(*iii*) *Type 3 construction.* All structural components have 2-hours fire resistance.

(*iv*) *Type 4 construction.* All structural components have 1-hour fire resistance.

Experience shows that with fire fighting equipment installed in the premises, the duration of fire in buildings having a fire load between 500000 to 1100000 k cal/m² is usually less than 3 hours. Hence type 1 construction prescribed for this class of buildings generally ensures sufficient protection. However, in buildings covered under type 1, proper ventilation and provision for escape of hot gases should be made. Also, when fire fighting equipment or the services of a fire brigade are available in the premises, the design should provide for immediate access from several positions.

The most satisfactory condition of a building is when it is constructed to resist a complete burn out of combustible contents, without failure or collapse.

23.6 CHARACTERISTICS OF FIRE RESISTING MATERIALS

An ideal fire resisting material should possess the following characteristics:

1. The material should not disintegrate under the effect of great heat.

2. The expansion of the material due to heat should not be such that it leads to instability of the structure of which it forms a part.

3. The contraction of the material due to sudden cooling with water (during fire extinguition process) after it has been heated to a high temperature should not be rapid.

In relation to fire, building materials can be divided into two types: (*i*) *non-combustible materials*, and (*ii*) *combustible materials*. *Non-combustible materials* are those which if decomposed by heat will do so with absorption of heat (*i.e.* endothermically) or if they oxidise, do so with negligible evolution of heat. These materials do not contribute to the growth or spread of fire, but are damaged and decomposed when high temperatures are reached. Examples of non-combustible materials are: stones and bricks, concrete, clay products, metal, glass etc. *Combustible materials* are those which, during fire, combine exothermically with oxygen, resulting in evolution of lot of heat and giving rise to flame or glow. Such materials burn are also contribute to the growth of fire. Examples of these materials are : wood and wood products, fibre board, straw board etc.

23.7 FIRE-RESISTING PROPERTIES OF COMMON BUILDING MATERIALS

1. Stone

Stone is a non-combustible building material and also a bad conductor of heat and does not contribute to the spread of fire. However, it is a *bad* fire-resisting material since it is liable to disintegrate into small pieces when heated and suddenly cooled, giving rise to failure of structure. Granite, on exposure to severe heat, explodes and disintegrates. Lime stone is the worst, since it is easily crumbled even under ordinary fire. Sand stone of compact composition (fine grained) can, however, stand the exposure to moderate fire without serious cracks. *In general, the use of stone in a fire-resisting construction should be restricted to a minimum.*

2. Bricks

Brick is a poor conductor of heat. First class bricks moulded from a good clay can stand exposure to fire for a considerable length of time, up to temperatures of about 1200°C. Brick masonry construction, with good mortar and better workmanship, is the most suitable for safeguarding the structure against fire hazards.

3. Concrete

The behaviour of concrete during exposure to heat varies with the nature of coarse aggregate and its density, and the quality of cement. It also depends upon the position of steel in concrete. Aggregates expand on heating while ordinary cement shrinks on heating. These two opposite actions may lead to spalling of the concrete surface. Aggregates obtained from igneous rocks containing higher calcareous content, tend to crack more while the aggregates like foamed slag, cinder and bricks are better. The cracks formed in concrete generally extend to a depth of about 25 mm. Hence reinforced concrete fire-resistant construction should have greater cover. *In general, concrete offers a much higher resistance to fire than any other building material.* Reinforced concrete structures can withstand fire lasting for several hours with a temperature of 1000°C without serious damage.

4. Steel

Though steel is non-combustible, it has very low fire resistance, since it is a good conductor of heat. During fire, it gets heated very soon, its modulus of elasticity reduces and it looses its tensile strength rapidly. It is found that yield stress of mild steel at 600°C is about $\frac{1}{2}$ of its value at normal temperatures. Hence unprotected steel beam sags and unprotected columns or struts buckle, resulting in the collapse of structures. If the surface paint on these steel components, is not fire resistant, it is essential to protect structural steel members with some coverings of insulating materials like brick, terracotta, concrete etc. Fixing of steel in plate or sheet form to the structural steel frame work is also effective in resisting the passage of flame. Such construction is widely used in making fire-resisting doors and windows.

5. Glass

Glass is poor conductor of heat, and its thermal expansion is also less. When it is heated and then suddenly cooled, cracks are formed. These cracks can be minimised if glass is reinforced with steel wire netting. Thus, *reinforced glass* is more fire resistant, and can resist variations in temperature without serious cracks. Reinforced glass has higher melting point. Even if cracks are formed, the embedded wires hold the cracked portion in position. Reinforced glass is therefore commonly used for fire-resisting doors, windows, done sky-lights, etc.

6. Timber

Timber is a combustible material. It ignites and gets rapidly destroyed during fire, if the section is small. However, if timber is used in *thick* sections, it possesses the properties of self-insulation and slow burning. During exposure to fire, timber surface gets charred; this charred portion acts as protective coating to the inner portion. However, if the temperatures are higher than 500°C, timber gets dehydrated under continued exposure, giving rise to combustible volatile gases which readily catch fire. In order to make timber fire-resistant, the following measures are adopted:

(*i*) use of thicker sections at wider spacing than thinner sections at closer spacing, specially in case of floor joints, (*ii*) reducing number of corners and area of exposed surfaces to a minimum, (*iii*) coating timber surface with chemicals like ammonium phosphate and sulphate, borax and boric acid, zinc chloride, (*iv*) painting timber surfaces with asbestos or ferrous oxide paints, if painting is necessary. Painting these with oil paints or varnish should not be done since these paints catch fire.

7. Cast-iron and wrought iron

Cast iron behaves very badly in the event of fire. On sudden cooling, it gets contracted and breaks down into pieces or fragments, giving rise to sudden failure. Hence it is rarely used in fire-resistant building unless suitably covered by bricks, concrete etc. Wrought iron behaves practically in the same way as mild steel.

8. Asbestos cement

It is formed by combining fibrous asbestos with Portland cement. It has low coefficient of expansion and has property of incombustibility. It has, therefore, great fire-resistance. Asbestos cement products are largely used for construction of fire-resistant partition walls, roofs, etc. It is also used as protective covering to other structural members.

9. Aluminium

It is very good conductor of heat. It has very poor fire-resistant properties. Its use should be restricted to only those structures which have very low fire risks.

10. Plaster or mortar

Plaster is non-combustible. Hence it should be used to protect walls and ceilings against fire risks. Cement plaster is better than lime plaster since the latter is likely to be calcined during fire. The fire-resistance of plaster can be increased by using it in thick layers or reinforcing it with metal laths. Gypsum plaster, when used over structural steel members, make them better fire-resistant.

23.8 GENERAL FIRE SAFETY REQUIREMENTS FOR BUILDINGS

In order that the fire hazards (*i.e.*, personal hazard, internal hazard and exposure hazards) are minimised, IS: 1641–1988 recommends that the buildings shall conform to the following general requirements:

1. All buildings and particularly buildings having more than one storey shall be provided with liberally designed and safe fire-proof exits or escapes.

2. The exits shall be so placed that they are *always* immediately accessible and each is capable of taking all the persons on that floor as alternative escape routes may be rendered unusable and/or unsafe due to fire.

3. Escape routes shall be well-ventilated as persons using the escapes are likely to be overcome by smoke and/or fumes which may enter from the fire.

4. Fire-proof doors shall conform rigidly to the fire safety requirements.

5. Where fire-resisting doors are employed as cut-offs or fire breaks, they shall be maintained in good working order so that they may be readily opened to allow quick escape of persons trapped in that section of the building, and also, when necessary, prompt rescue work can be expeditiously carried out.

6. Electrical and/or mechanical lifts, while reliable under normal conditions may not always be relied on for escape purposes in the event of a fire, as the electrical supply to the building itself may be cut-off or otherwise interrupted, or those relying on mechanical drive may not have the driving powder available.

7. Lift shafts and stairways invariably serve as flues or tunnels thus increasing the fire by increased drought and their design shall be such as to reduce or avoid this possibility and consequent spread of fire.

8. False ceiling, either for sound effects or air-conditioning or other similar purpose shall be so constructed as to prevent either total or early collapse in the event of the fire so that persons underneath are not fatally trapped before they have the time to reach the exits; this shall apply to cinemas, and other public or private buildings where many people congregate.

9. To a lesser extent, the provisions of clause (8) above shall apply to single-storey buildings which may be used for residence or an equivalent occupancy. Whatever be the class or purpose of the building, the design and construction shall embody the fire retardant features for ceilings and/or roofs.

10. ***Floors.*** Floors are required to withstand the effects of fire for the full period stated for the particular grading. The design and construction of floors shall be of such a standard that shall obviate any replacement, partial or otherwise, because experience shows that certain types of construction stand up satisfactorily against collapse and suffer when may first be considered as negligible damage, but in practice later involves complete stripping down and either total or major replacement. This consideration shall also be applied to other elements of structure where necessary.

11. ***Roofs.*** Roof for the various fire-grades of the buildings shall be designed and constructed to withstand the effect of fire for the maximum period for the particular grading, and this requires concrete or equivalent construction. It is, however, important that maximum endurance is provided for as stated in para 9.

12. ***Basements.*** Where basements are necessary for a building and where such basements are used for storage, provision shall be made for the escape of any heat arising due to fire and for liberating and smoke which may be caused. It is essential that fire resistance

of the basement shall conform to the highest order and all columns for supporting the upper structures shall have a grading not less than laid down in types 1 to 3.

13. ***Smoke extraction from basements***. The following requirements shall be provided for smoke extraction:

(*a*) Unobstructed smoke extracts having direct communication with the open air shall be provided in or adjoining the external walls and in positions easily accessible for firemen in an emergency.

(*b*) The area of smoke extracts shall be distributed, as far as possible, around the perimeter to encourage flow of smoke and gases where it is impracticable to provide a few large extracts, for example, not less than 3 m^2 in area, a number of small extracts having the same gross area shall be provided.

(*c*) Covers to the smoke extracts shall, where practicable, be provided in the stall board and/or pavement lights at pavement level, and be constructed of light cast iron frame or other construction which may be readily broken by fire-men in emergency. The covers shall be suitably marked.

(*d*) Where they pass through fire resisting separations, smoke extracts shall in all cases be completely separated from other compartments in the building by enclosures of the appropriate grade of fire resistance. In other cases, steel metal ducts may be provided.

(*e*) Where these are sub-basements, the position of the smoke extracts from sub-basements and basements shall be suitably indicated and distinguished on the external faces of the building.

23.9 FIRE RESISTANT CONSTRUCTION

In a fire resistant construction, the design should be such that the components can withstand fire as an integral member of structure, for the desired period. We shall consider the construction of the following components:

1. Walls and columns.
2. Floors and roofs.
3. Wall openings.
4. Escape elements.
5. Strong room construction.

1. Walls and columns

The following points should be observed for making walls and columns fire-resistance:

(*i*) Masonry walls and columns should be made of thicker section so that these can resist fire for a longer time, and can also act as barrier against spread of fore to the adjoining areas.

(*ii*) In the case of solid load-bearing walls, bricks should be preferred to stones.

(*iii*) If walls are to be made of stones, granite and lime stone should be avoided.

(*iv*) In the case of building with framed structure, R.C.C. should be preferred to steel.

(*v*) If steel is used for the framed structure, the steel structural components should be properly enclosed or embedded into concrete, terracotta, brick, gypsum plaster board, or any other suitable material, as illustrated in Fig. 23.1.

(vi) If the frame work is of R.C.C., thicker cover should be used so that the members can resist fire for a longer time. It is recommended to use 40 to 50 mm cover for columns, 35 to 40 mm cover for beams and long span slabs and 25 mm for short span slabs.

(vii) Partition walls should be of fire-resistant materials such as R.C.C., reinforced brick work, hollow concrete blocks, burnt clay tiles, reinforced glass, asbestos cement boards or metal laths covered with cement plaster.

(viii) Cavity wall construction has better fire resistance.

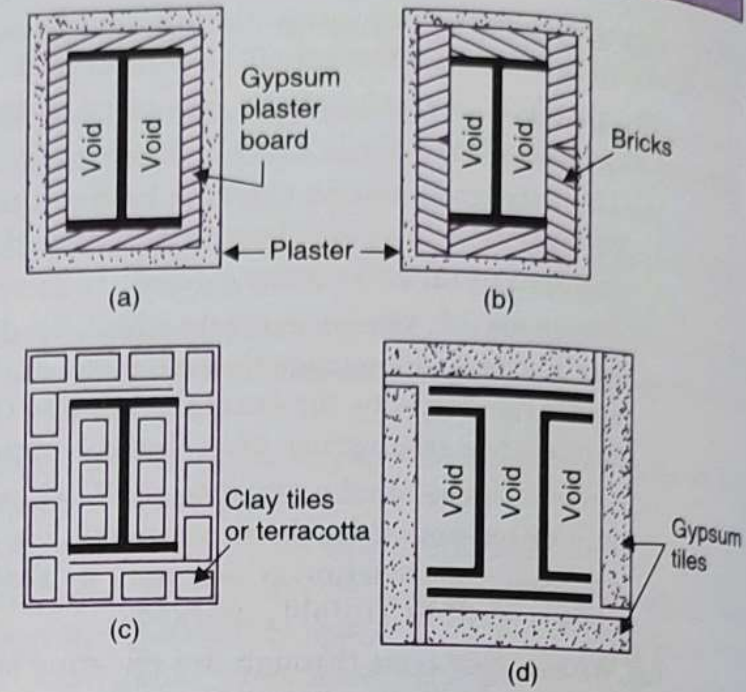

Figure 23.1. Protection of Steel Components

(ix) All walls, whether load bearing or non-load bearing, should be plastered with fire-resistive mortar.

2. Floors and roofs

The following points are note-worthy for fire-resistant floors and roofs:

(i) For better fire resistance, slab roof is preferred to sloping or pitched roofs.

(ii) If it is essential to provide sloping roof, trusses should either be of R.C.C. or of protected rigid steel with fire proof covering.

(iii) For better fire resistance, the floor should be either of R.C.C. or of hollow tiled ribbed floor or of concrete jack arch floor with steel joists embedded in concrete.

(iv) If floor is made of timber, thicker joists at a greater spacing should be used, and fire stops or barriers should be provided at suitable interval.

(v) The flooring materials like concrete tiles, ceramic tiles, bricks etc. are more suitable for fire resistance.

(vi) If cast iron, wrought iron, cork carpet, rubber tiles etc. are to be used, these should be protected by a covering of insulating materials like ceramic tiles, plaster, terracotta, bricks etc.

(vii) Ceiling, directly suspended from floor joists should be of fire resistant materials like asbestos cement boards, fibre boards, metal lath with plaster etc.

3. Wall Openings

(i) From the point of view of fire spread, openings in the walls should be a bare minimum.

(ii) Openings serve means of escape. Hence these should be properly protected by suitable arrangements, in case of fire.

(iii) Doors and windows should be made of steel. Fire-resistance doors can be obtained by fixing steel plates to both the sides of the door.

(iv) Wire-glass panels are preferred for windows.

(v) Rolling shutter doors should be used for garages, godowns, shops etc.

(vi) In case of timber doors, minimum thickness of door leaf should be 4 cm and that of door frame as 8 to 10 cm.

(vii) All escape doors should be such as to provide free circulation to the persons in passages, lobbies corridors, stairs etc., and should be made of fire proofing material.

4. Escape **Elements**

(i) All escape elements, such as stair cases, corridors, lobbies, entrances etc. should be constructed of fire-resistant materials.

(ii) These escape elements should be well separated from the rest of the building.

(iii) Doors to these escapes should be fire proof.

(iv) Staircases should be located next to the outer wall and should be accessible from any floor in the direction of flow towards the exits from the building.

(v) Fire proof doors to the emergency stair cases should be fixed in such a way as to make them close from inside only.

(vi) The lift shafts connecting various floors should be surrounded with the enclosure walls of fire-resisting materials.

(vii) Lift shafts should be vented from top to permit escape of smoke and hot gases.

(viii) An emergency ladder should be provided in the fire-resisting building. This ladder should be at least 90 cm wide, constructed of fire-resistant materials.

(ix) All escape routes over roofs should be protected with railings, balustrades or parapets not less than one metre in height.

5. Strong **room construction**

A strong room construction is found to be useful in case of safe deposit vaults in banks. Following are the important features of construction:

(i) The walls, floors and ceilings of a strong room are made of at least 30 cm thick cement concrete. If thin R.C.C. walls are used, they should be have covering of bricks or terracotta and then suitably plastered with fire-resistant plaster.

(ii) Doors and windows are well anchored to concrete walls by large number of steel hold fasts longer in length.

(iii) Doors and windows should be fire-proof. It is preferable to have double fire-proof door.

(iv) Windows and ventilators should be covered by special grills made of 20 mm steel square bars. These grills should be well fixed to concrete walls by means of long steel hold fasts.

23.10 FIRE ALARMS

Fire alarms are installed to give an alarm and to call for assistance in event of fire. The fire alarms give enough time to the occupants to reach to a safe place. Fire alarms can be either manual or automatic.

1. **Manual alarms**

These are of a hand-bell type or similar other sounding device, which can emit distinctive sound when struck. These are sounded by watchmen and the occupants are thereby warned to have safe exit in shortest possible time. Manually operated alarms shall be provided near all main exits and in the natural path of escape from fire, at readily accessible points which are not likely to be obstructed.

2. Automatic alarms

These alarms start sounding automatically in the event of fire. It is used in large industrial buildings which may remain unoccupied during night. The automatic fire alarm sends alarm to the nearest control point. The system can also perform the function of sending message to the nearest fire brigade station.

23.11 FIRE EXTINGUISHING EQUIPMENTS

Each building should have suitable fire extinguishing arrangements, depending upon the importance of the building and the associated fire hazards. Following are usual equipments required for fire extinction.

1. Manual fire extinguishing equipment

These devices are useful for extinguishing fire as soon as it starts. They are not so useful when once the fire has spread. Under this category comes the portable extinguishers of carbon-dioxide type or foam generation type etc. The discharge from a portable fire extinguisher lasts only for a short duration of 20 to 120 seconds. In some cases, specially in small buildings buckets of water, sand and asbestos blanket may be kept ready at all times to extinguish fire. These buckets are installed at convenient locations for taking care of fire of minor size.

2. Fire hydrants

These fire hydrants are provided on a ring main of 150 mm dia., in the ground around the building periphery. The ring main gets water from underground tank with pressure so that available pressure at each hydrants is of the order of about 3.5 to 4 kg/cm^2.

3. Wet riser system

The system consists of providing 100 to 150 mm dia. vertical G.I. pipes (risers) at suitable locations in the building. A fire pump is used to feed water from underground tank to these pipes, to ensure a pressure of 3 kg/cm^2 at uppermost outlet.

4. Automatic sprinkler system

This arrangement is adopted for important structures like textile mills, paper mills etc. The system consists of a net work of pipes 20 mm dia. fixed to the ceiling of the room. These pipes are spaced at 3 m centre to centre. Heat actuated *sprinkler heads* are fixed to these pipes at regular interval. The pipes get supply from a header. Each sprinkler head is provided with fusible plug. In the event of fire, the fusible plug in the sprinkler nearest to the wire melts due to rise of temperature, and water gushes out of the sprinkler head. The fire is thus brought under control in a short period.