RESEARCH ARTICLE OPEN ACCESS

Fire Suppression Systems for High Rise Buildings in India: Review Article

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Abstract:

Fire protection systems are designed to stop the fire from spreading and it aims to suppress the fire and control the damage. Averting the fire from spreading alleviates losses and permits time for emergency team to respond. The design of a building and type of materials used in the construction are the significant factors while defining the fire resistance of a building. These factors are also important in controlling the fast spread of fire and smoke, otherwise it may lead to the loss of lives and property. Installation of passive fire protection system requires necessary planning in the design stage of a building. Implementation of passive fire protection system in the existing building is a tough task and expects many alterations in the architectural and structural features of a building. The best possible way to achieve the objectives of fire extinction in a building is to develop a balanced fire protection system that includes best design features of both passive and active fire protection systems. As the installation of passive fire protection system in existing building requires many alterations and it's not cost effective, hence an active fire protection system has been concentrated here in this review paper. At the same time, it is equally important to impart an education and training to the personnel to operate the fire situation as well as effective handling of firefighting installations in the event of fire.

Keywords **—fire protection system, sprinklers, fire detection and alarms, fire extinguishers, extinguishing agents or media.**

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1. INTRODUCTION

The buildings occupied for living, assembly, business, education, industry or for any other purpose, forms a major constituent of human habitation. As a part of socio-economic development of the nation, the steady urbanisation is gathering momentum in the nation. There has been massive growth in the number of constructions, especially in the urban and surrounding areas, including high-rise and special buildings. The ability of a building to identify, sustain, avert and reduce any damage to the building because of a sudden un-expected cause of fire refers to the fire safety of a building. With the increased technological advances in building constructions, the fire hazards for the buildings have also been increased. These fire hazards are responsible in causing substantial damage to the occupants and their assets. This has given the fresh challenges to architects and fire protection service providers to develop an enhanced designs of buildings and fire protection methods to diminish such losses.

Bureau of Indian Standards were published their first version of the National Building Code (NBC) in 1970 and then onwards it was revised subsequently. The part 4 of latest NBC 2016 is dealing exclusively with the fire and life safety in India [1, 2]. Similarly other countries have also

documented their building codes and consequently revised. The entire objective of this regulatory document is to make sure about the accomplishment of basic standards of constructions, including fire and life safety in all types of buildings. As the architectural and structural designs of a building have substantial effect on the fire safety of a building, hence fire protection systems for the buildings have been divided in to active and passive kinds [5]. In the event of fire, both of these systems will ensure an extensive fire safety of the buildings. The absolute safety of a building from fire is very rare in practice. The extent of fire can be minimized by implementingthe right fire protection measures with the classification of buildings as per nature of activities pursued in the building. Although fire is a good friend of humanity, but when it spreads rapidly in the buildings, it gives heavy loss to the property and lives. Therefore fire protection measures, have a great role in the safety of a building [3].

Fire and life safety is not only connected with the safety of occupants and their assets, but it is related with the type of occupancy and design features of buildings also. An attempt has been made here through this review paper to enlighten and enhance the understanding about fire characteristics, fire suppression systems and their implementation [4, 6, 7].

Figure 1. Building caught in fire.

2. OBJECTIVES

The objectives are:

1. Save lives and protect the property.
2. Minimize the interruptions of services due to fire

3. FIRE SCIENCE AND CONSTITUENTS OF FIRE

An understanding about the fire science is essential for knowing the principles of fire control. Also this will help to identify the origin and source of fire to control its growth and spread as well as its extinction. Combustion or fire is an exothermic reaction between the fuel and oxygen. This reaction happens rapidly and generates heat at faster rate than its dissipation, which gives instantaneous rise in temperature. This rise in temperature increases rapidly and a visible light or flame is generated.

3.1 Fire Triangle

It has been understood that for the existence of a fire, heat, oxygen and combustible material, these three factors or constituents are essential. Fire will burn until each of these three constituents are present. Removal of one or more of these factors or constituents from the fire leads to the collapse of fire triangle and stops the fire.

Fire is the process of burning, initiated in the presence of heat energy, where a combustible material reacts with oxygen from the atmosphere. This reaction will release the energy in the form of heat, light and sound. The heat energy is essential to ignite the fire, heat increases the temperature of fuel to auto ignition and that origins the fire.

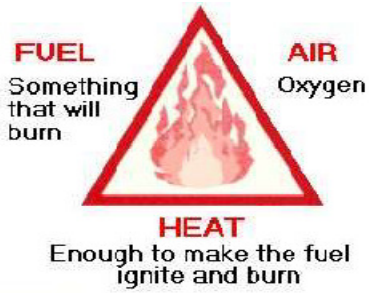

Figure 2. Fire Triangle.

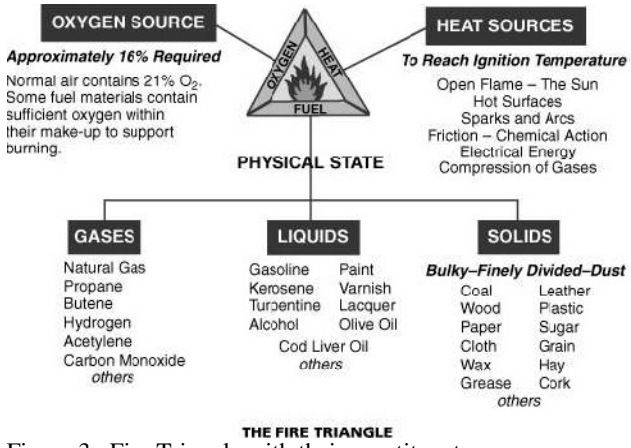

Figure 3. Fire Triangle with their constituents

4. CLASSIFICATION OF FIRES

Fires have been categorised according to the kind of fuel engaged in combustion. The fuels may be solid, liquid or gaseous type and depending up on the type of fuel, fires are classified as:

4.1 Class "A" Fires

This type of fire includes, a solid or fibrous material such as wood, paper, rubber, cloth, plastic etc. of an organic nature as a fuel. This type of fires are most common and generally occurs with the formation of coal or ash. Generally preferred extinguishing media in this type of fire is water.

Figure 4. Fuels of Class A fire.

4.2 Class "B" Fires

This type of fire includes, a liquid or liquefiable solids such as gasoline, oils, paints, kerosene, grease and flammable gases etc. as a fuel. The flammable liquids can be segregated into following categories to choose an effective extinguishing media.

1. Miscible with water, and
2. Immiscible with water.

Considering whether it is miscible or immiscible with water, the extinguishing media such as water, foam, vaporizing liquids, inert gases and chemical powders may be preferred for fire extinction.

Figure 5. Fuels of Class B fire.

4.3 Class "C" Fires

These are the fires that involves energized electrical equipment's, fixtures and fittings etc. as a combustible material. In such fire events, it is preferred to switch off the electricity and use an appropriate extinguishing media to control the fire. Dry chemical powder, carbon-di-oxide and other inert gases can be used as an extinguishing agents to control the fire.

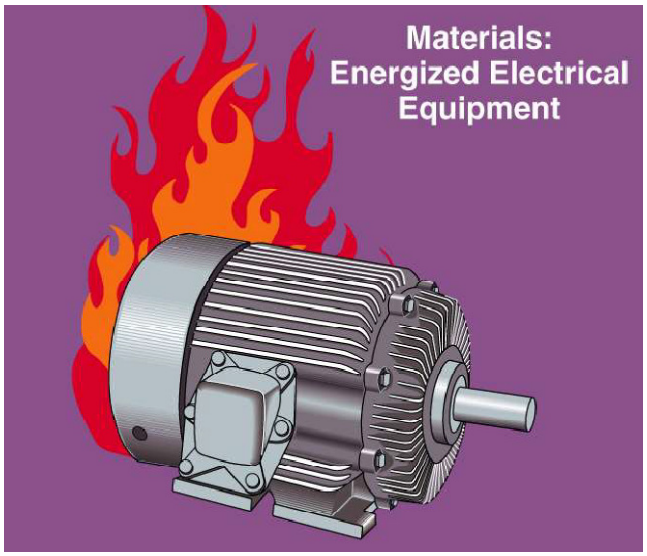

Figure 6. Fuels of Class C fire.

4.4 Class "D" Fires

These are the fires involving combustible metals such as magnesium, titanium, zirconium, sodium, lithium, potassium etc. In this type of fire, the extinguishing media comprising water are not effective, rather it is hazardous. Normally dry chemical powder or dry sand can be preferred as an extinguishing agent in this type of fires.

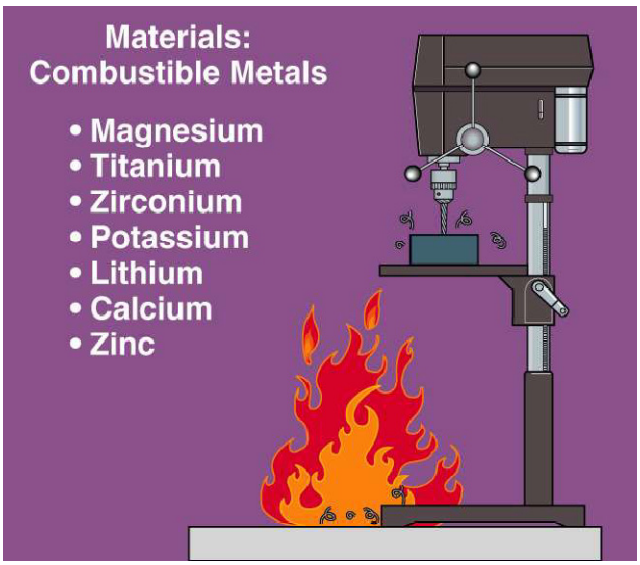

Figure 7. Fuels of Class D fire.

4.5 Fire Load

This is defined as the quantity of heat liberated in kilojoule (kJ) per unit area of the floor by the burning of materials in the building including combustible portion of the building. Based on the quantity of heat liberated, buildings may be categorised into low, moderate and high hazard occupancy.

5. FIRE PROTECTION MANAGEMENT

It is impractical to achieve the objective of complete fire prevention in the building at this stage, because several unpredictable factors are bound to occur. The finest potential way to attain this objective is to employ a balanced fire protection system that includes best design features

of both passive and active fire protection systems [1, 8].

It is essential to aware and inform the building occupants regarding fire suppression systems installed in the buildings. So that they will understand the intent of these systems and the same can be executed in better way in the event of fire.

5.1 Passive Fire Protection

This system involves use of fire-resistant building construction materials. This also includes the installation of fire doors and fire rated assemblies to cover the openings in the buildings. The formation of fire compartments will limit the spread of fire and smoke throughout the buildings. This system is an integral part of building fire protection. This attempts to cover the fires or slow down the spread of fire through the use of fire-resistant assemblies and construction materials in the buildings. To accomplish these aims of passive fire protection, in the planning phase of a building itself, it has been planned for the safe exit or escape of the occupants with the shortest possible way in case of fire. Also different types of fire-resistant materials have been preferred to employ in the construction stage of buildings. This system is independent and does not require any kind of external activation to get into the firefighting operation in the event of fire.

5.1.1 Fire Escapes

It is an emergency exit, usually provided outside of the building or sometimes may be employed inside of a building but distinct from the core areas of the building.

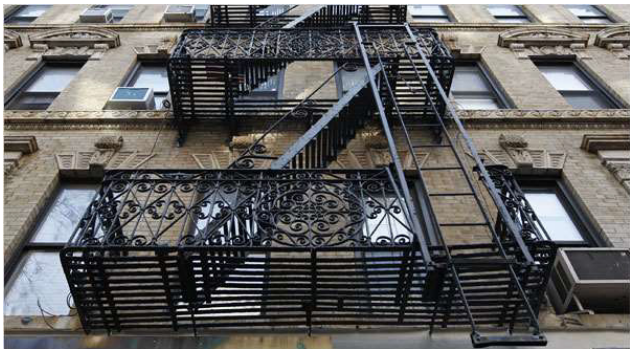

Figure 8. Fire escape arrangement outside the building

Figure 9. Fire escape arrangement outside the building

In the event of fire or in case of emergency, this offers an alternative way to escape when the staircases inside the building are unapproachable. It is essential to provide the fire escapes in multiple-story residential buildings.

5.1.2 Escape Chute

It is an alternate way of exit in the event of fire. Mostly preferred where usual fire escape stairwells are not possible to install. This is a fabric or metallic conduit mounted near the exit at any convenient floor of a building. As and when required, it will be installed and protected at the lower end by firemen, away from the building.

Once installed, escapees can pass through the conduit and descend to the ground level.

Figure 10. Fire escape chute: metal tube

Figure 10. Fire escape chute: fabric tube

5.2 Active Fire Protection

This system involves the use of fire protection installations in the building that reacts in case of a fire. This system requires certain amount of motion or action to activate and operate in the event of fire. This action may be manual for operating fire extinguishers or automatic in case of sprinkler system, but in both the cases, this system require certain amount action to actuate. This system includes fire detection system, automatic sprinkler systems, fire hydrants and fire extinguishers as well as firefighters. Fire or smoke operated detection and alarm systems are used to identify and alert the occupants about the fire in buildings. Automatic sprinkler systems installed in the building will slow down the spread of fire and its growth. Whereas firefighters with the help of these active fire protection systems can control and suppress the fire.

As per the recent building codes, installations of fire detectors, fire alarms, automatic sprinkler systems, use of advanced firefighting equipment's including firefighting ladder trucks and mechanisms of better communications in case of emergency have been recommend to get in practice.

Figure 11. Firefighting ladder truck

6. FIRE SUPPRESSION SYSTEMS

Fire protection systems are designed and installed in the buildings to control the spread of fire. This system aims to stop the fire and prevent the losses of lives and assets [2, 10]. Preventing the spread of fire, permits time for emergency personnel to respond.

The integrated system of fire protection which combines features of both passive and active fire protection systems are more effective to extinguish the fire. Implementation of passive system is highly convenient and cost effective in the construction stage of a building, but it requires many alterations for its making in existing buildings and practically which may not feasible. Hence, considering the existence of many buildings, an active fire protection system has been concentrated here in this review paper.

As it has been understood from the fire triangle that the presence of three factors (fuel, oxygen, heat) are essential for the cause of fire, so the active fire protection system consists of either removal or control of one or more of these aspects. Accordingly active fire protecting systems may be classified as:

1. Starvation (limitation of fuel)
2. Smothering (limitation of oxygen)
3. Cooling (limitation of temperature)

6.1 Starvation

The extinction of fire in this method is achieved either by removal of combustible material from the region of fire or by taking away the fire from region of combustible material.

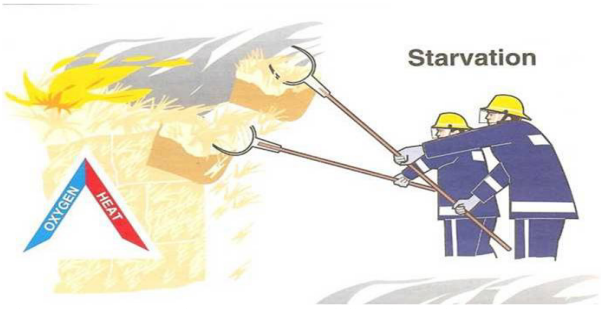

Figure 12. Starvation: removal of fire from fuel

Figure 13. Starvation: removal of fuel from fire

6.2 Smothering

The combustion or fire process will cease, if the oxygen level in the vicinity region of burning substance is adequately reduced. This method of fire control, restricts the access of fresh air to the region of fire and allows the fire to reduce the oxygen level in the confined atmosphere to extinguish the fire.

In case of a domestic or small fires, if the fire is covered with blanket, it will terminate the supply of air and extinguish the fire.

Smothering is mainly achieved by the usage of a foam, which creates a viscid layer above the burning substance and terminates the supply of air. Another way of smothering is the application of a fine dry powder instead of a foam from the pressurized extinguisher.

The forceful discharge of an inert gas either carbon-di-oxide or nitrogen in the region of fire can temporary reduce the oxygen level of atmosphere and that extinguishes the fire.

Figure 14. Smothering: fire covered with blanket

Figure 15. Smothering: fire covered with dry powder

Figure 16. Smothering: fire covered with CO_2

Figure 17. Smothering: fire covered with foam

6.3 Cooling

If the rate of heat generation in the fire process is less than the rate of heat dissipation then fire process may not continue. The usage of water in the form of a jet or spray to fire is inevitably built on this fundamental principle.

This cooling principle is most commonly employed in fire extinction. It sprays water or other liquids on burning materials to extinguish the fire.

The effectiveness of liquid in fire extinction depends on its thermal capacity and latent heat of vaporization. On this basis, water is most effective fire extinguishing media. As water is available in huge quantity, this makes it most suitable fire extinguishing media for general purpose. In fact, water expands during the phase change from liquid (water) to vapour (steam) and which gives smothering effect to contribute in fire suppression. Water should be applied to fire in such a way that most of it should get converted in to steam. The steam generated at the region of fire contributes in fire extinction in the way of smothering.

Figure 17. Cooling: spraying of water on fire

Figure 18. Cooling: spraying of water on fire

6.4 Extinguishing Agents or Media

The selection of fire extinguishing agent depends on the type of fire. This media is essential to control the fire or extinguish the fire.

Types of firefighting media are:

1. Water
2. Foam
3. Inert gases
4. Chemical powders

7. FIRE SUPPRESSION EQUIPMENT & INSTALLATIONS

This deals with the equipment's or installations of active fire protection system in a building. These are mainly divided in three phases [1, 2].

1. Fire Detection and Alarm Systems
2. Fixed Firefighting Systems
3. First Aid Firefighting Installations

Fire protection is typically achieved in the existing building by the installation of these three stages of active fire protection system. Active fire protection system actuates once fire is detected.Fire detection, fire alarm systems and firefighting systems are fixed installations whereas first aid firefighting installations are movable. Automatic sprinkler system is a fixed firefighting installation and it has ascertained to be the most effective way of fire control in the buildings. Knowledge about the main principles involved in their installation is necessary to understand their capabilities and applications. Apart from this trained persons are expected to maintain and operate such installed fire protection systems.

7.1 Fire Detection and Alarm Systems

An appropriately designed, installed and maintained automatic fire detection and alarm system plays an important role in case of a fire for protecting the lives and minimizing the loss of property [2, 9]. The prime objective of this system is to reduce the time delay, which may follow a serious fire outbreak in the building. In the event of fire, the first five minutes are more important than the next five hours.

Fire detectors sense the characteristics of fire i.e. heat, smoke and flame. Detection of any one characteristic may not be suitable for all applications. The proper selection of fire signature is highly essential to achieve the objective of fire protection system.

7.1.1 Heat Detectors

1. Fixed Temperature Detectors: detecting the pre-determined temperature
2. Rate-of-Rise Detectors: detecting quick temperature rise

7.1.2 Smoke Detectors

1. Ionization Detector
2. Optical Detector

7.1.3 Flame Detectors

1. Infra-red Detector
2. Ultra-violet detector
3. Multi-sensor fire detectors

The fire detectors will detect fire and actuate the alarm system. Any fire protection system includes fire detection and fire alarm system as its integral part. Fire is easy to extinguish in its initial stage. Alarm system will alert the people and evacuation of buildings becomes easy. This helps for

immediate evacuation of the premises and activation of firefighting systems.

The detailed guidelines regarding selection and installation of fire detection and alarm systems for buildings have been given in the recent National/International Standards like IS : 2189 : 2008, BS : 5839 : Part-1 : 2017, NFPA-72 : 2019 etc. This may be referred for further details.

7.2 Fixed Firefighting Systems

The fixed firefighting systems with water as main extinguishing media is very common in use to control the fire. Fire protection system includes discharge of water through the pipes for fire extinction. Water may be supplied through the riser pipes connected with the overhead and underground tanks. A riser or standpipes may be fed by a pump installed at site or from a fire engine connected to fire pillar near the street for supply of water in case of fire.

Hydrant systems are mainly classified as external hydrant system and internal hydrant system.

7.2.1 External Hydrant System

This hydrant systems are installed outside the buildings, like in the open areas in cities or towns and industries. This system is essential for firefighting in cities and other individual occupancies.

In developed countries, major cities are provided with the well maintained water mains. This is either combined with domestic water supply or may be a separate firefighting hydrant. In case of a fire, fire service vehicles get connected to these hydrants and draw water from them to carry out firefighting operations. In most of the developing nations such reliable hydrant water mains are not available, hence internal hydrant systems are mainly responsible for water supply in firefighting operations.

Figure 19. Pillar or post hydrant

Pillar or post hydrants are connected to underground water mains and remains standing above ground level about 1m. It consists of more than one outlets to serve number of fire tenders at a time. They are painted in red and always kept in working condition.

7.2.2 Internal Hydrant System

Internal hydrant systems are installed for safeguard of buildings from fire. This system mainly consists of underground water tank, overhead water tank, riser, firefighting pumps, hose reels, branch pipes, and valves etc. The required capacities of underground and overhead water tanks may vary as per the fire load of buildings. Internal hydrant systems are further classified as:

1. Dry Riser System
2. Wet Riser System

7.2.3 Dry Riser System

This system is normally not charged with water. But, as and when required this system may be

charged through the fire service inlet, connecting with the firefighting pump. Also it can be charged by directly connecting with the fire engine. This system is normally used and operated by firefighters.

Dry riser system includes installation of riser pipes, branches, sprinklers and water distribution arrangement in the entire building without running water.

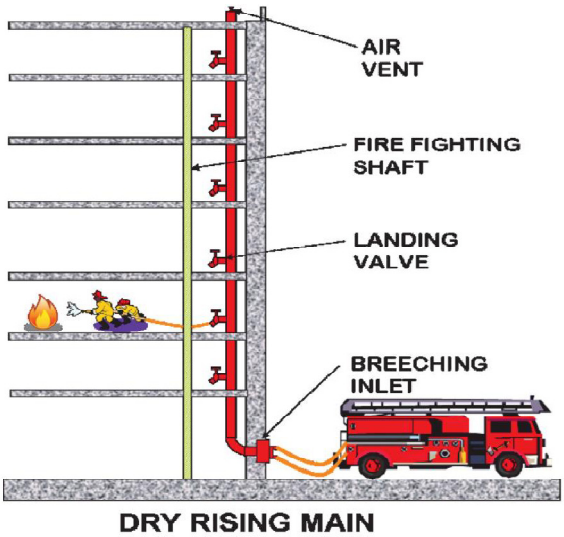

Figure 20. Dry riser system

This system is preferred in the regions where atmospheric temperature goes below the freezing point of water. In such regions dry risers are preferred to protect the buildings in the event of fire. This system will avoid the possibility of bursting because of ice formation in the pipes and leakages of water in the buildings.This system may be operated automatically or manually in the event of fire.

Automatic sprinklers discharge the water when temperature of air near the sprinkler reaches to predetermined level.
When the fuse of the sprinkler melts due to heat of fire, water flows through the sprinkler head quickly to extinguish the fire.

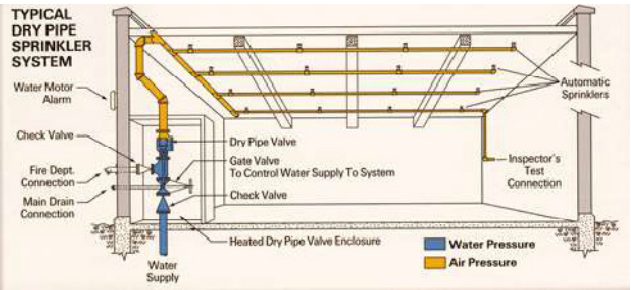

Figure 21. Dry pipe sprinkler system

7.2.4 Wet Riser System

This system always remains charged with water. In the event of fire, it responds immediately to extinguish the fire. This system is connected to the overhead water tank through booster pump. Bottom end of riser is connected to the firefighting pump with non-return valve installed at underground tank. This system may also be charged by fire engine, connecting through the fire service inlet. Hose reels are installed at strategic points on all floors andtheyare directly connected with the main riser on each floor. Fire hose may be kept in a specially designed cabinet to view and access it immediately in the event of fire.

This system requires two separate firefighting pumps to be installed at underground water tank for independently feeding of wet risers. One of them will act as a standby pump and reserved for immediate deployment in service in case of emergency or failure of main operating pump. These pumps are operated with an independent source of power.

The main risers should be designed according to the height of building. This entire system should be tested for desired water pressure before taking in to operation.

Figure 22. Fire hose with holding cabinet

Figure 22. Fire hose reel

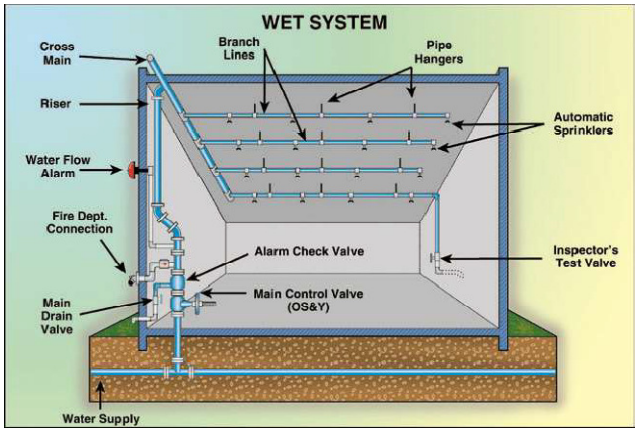

Figure 23. Wet pipe sprinkler system

7.2.5 Fire Suppression

The control of fire spread or its growth and fire suppression in the building may be accomplished either manually or automatically. The use of fire extinguishers and hydrant system in the event of fire needs manual actuation. Whereas automatic fire suppression system includes the fire sprinkler system or firefighting foam system.

Figure 24. Fire suppression by automatic sprinkler system: water as extinguishing agent

Figure 25. Fire suppression by automatic sprinkler system: foam as extinguishing agent

7.2.6 Sprinkler Systems

It is preferred to plan for the installation of a sprinkler system in the design stage of a building, whereas in the later stage it involves extensive renovation work.Automatic sprinkler systems are recommended for all types of buildings. This

system is usually mounted with ceiling and connected to a reliable source of water. Sprinkler nozzles are closed with a glass tube or fusible plug. Usually they are designed to melt at predetermined temperature to extinguish the fire by allowing water to fall on source of heat. Automatic sprinkler system helps to control the spread and growth of a fire, thereby protects the lives and property.

Sprinkler systems are mostly preferred for fire extinction in the occupancies such as residential apartments, educational complexes, hotels, hospitals etc. In the event of fire, sprinkler system responds immediately and supplies water to extinguish the fire, before it spreads. Also prevents access of air to the fire that gives smothering effect.

Sprinkler Classification:

The head of an automatic sprinkler is a fire extinguisher nozzle which is closed by a heat sensitive release element in a state of readiness. The sprinklers based on release may be classified as:

1. Fusible Element Sprinkler
2. Glass Bulb Sprinkler

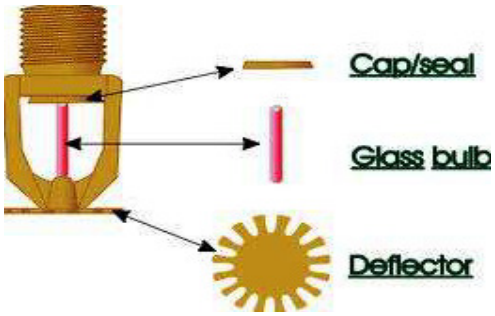

Figure 26. Glass bulb sprinkler

The sprinklers may be classified based on water distribution arrangement and they are as mentioned below:

1. Conventional Sprinkler
2. Umbrella Sprinkler
3. Sidewall Sprinkler

Conventional sprinkler distributes water in a spherical way, whereas umbrella sprinkler has parabolic type of water distribution arrangement. Sidewall sprinkler distributes water in half-parabolic way.

Figure 27. Different types of sprinklers

Figure 28. Components of firefighting system

7.2.7 Water Requirement for Firefighting System and Storage

The quantity of water required for fire extinction depends on extent of fire. Usage of potable water is highly preferred to avoid the possibility of health hazards in the later stage.

A sufficient quantity of water for the purpose of firefighting must be available within the premises. The required quantity of water may be stored in underground or overhead water tank. The tank capacity, firefighting pumps and other essential components of the system must be selected as per the standards and bylaws laid by the authorities.

7.3 First Aid Firefighting Installations

All types of fires starts at small. In the initial stage itself, if it has attempted immediately with appropriate extinguishing agent then it can be easily extinguished.

Portable fire extinguishers are particularly designed for handling of fires in their incipient stage. Now a

days, their usage for this purpose is very common in all types of occupancies. These fire extinguishers may be carried to the location of fire and operated to extinguish the same.

The extinguishers should be kept at visible locations on each floor to notice them in the normal way of escape.

According to the type of extinguishing media, portable fire extinguishers are classified as:

1. Water type extinguishers
2. Foam extinguishers
3. Dry chemical powder extinguishers
4. CO_2 extinguishers

7.3.1 Water Type Extinguishers

This type of extinguishers are filled with water and pressurized dry air. When a fire occurs, this type of extinguisher applies water in the form of a finely divided droplets and controls the fire by cooling effect.

7.3.2 Foam Extinguishers

This type of extinguishers are prepared with pre-mixed foam solution. The foam can be stored under pressure in the same container or a separate gas cartridge may be provided to operate. This is an effective method of fire extinguish. These are preferred to extinguish the fires of flammable liquids.

Figure 29. Fire extinguisher: Foam media

7.3.3 Dry Chemical Powder Extinguishers

Dry chemical powders have an excellent fire extinction properties. They are prepared with dry powder, maintained under pressure to operate. Container is normally provided with pressure gauge and nozzle.

This type of extinguisher has been preferred for fire extinction of A, B, and C class fires. The chemical powder used in this type of extinguisher is free flowing, water repellent and it will not give toxic effects, when used as a fire extinguisher media. Also these extinguishers are widely used in other high risk fires, because of its excellent firefighting effectiveness.

Figure 30. Fire extinguisher: Dry powder media

7.3.4 CO_2 Extinguishers

Carbon dioxide has been used as an extinguishing agent to extinguish the fires of flammable liquids and electrically energized equipment's. As carbon dioxide is heavier than air, it will displace the air above the burning material. This gives smothering effect to the burning surface. CO_2 does not participate in combustion and also it won't react with most of the materials. It is stored under pressure in the container to operate.

Figure 31. Fire extinguisher: CO_2 media

Figure 32. Fire extinguisher: operation

8. TRAINING, SERVICES & MAINTENANCE

Training for a personnel to handle the situation and operate the first aid fire extinguishers as well as fixed fire installations in high rise buildings is highly important [1,2,11]. But, normally this training part has been overlooked, whereas on the other side owner spent several hundred lackhs of rupees on the installation of best firefighting equipment's to protect the lives and property. In case of fire, people at the situation must respond immediately and utilize the available firefighting installations appropriately to control the fire. Hence prime importance should be given to the training part. Training for the security personnel should be arranged to use the firefighting installations and fire extinguishers in case of fire. Apart from this servicing and maintenance of firefighting installations is also important. It is recommended to decide the frequency of fire audit to be conducted in a year and as per the recommendations of fire auditor firefighting system may be upgraded.

Figure 33. Training to the personnel with fire hose

Figure 34. Training to the personnel with fire extinguisher

8.1 Safety Measures

It is important to follow certain precautions and awareness in the event of fire in the buildings.

- Inform the Fire Department.
- Encroachment or storage in courtyards or open spaces around the buildings are not allowed, as these spaces are needed for movement of fire tender & rescue appliances.
- Obstructions in the corridors and staircases are not allowed.
- Fire doors of staircases are kept closed to restrict the entry of smoke and fire in stairwell.
- Use the staircase and don't use the lift, lifts may fail in case of fire.
- Refuge area has to be kept open and free to access.
- Do not allow anyone to enter the fire affected building to collect any valuables.
- Make sure that firefighting water tanks are always kept with full of water.

- Do not allow to switch off the fire detection system.
- Do not switch off the electricity of entire building. Otherwise the firefighting system installed in the building may affect.
- Without consulting the fire officer, do not allow any work in the buildings.
- Make aware yourself with the fire protection system installed in the building along with their locations, escape route and refuge areas etc.
- Train yourself and security personnel about proper use of firefighting installations or fire extinguishers.
- It is recommended to conduct the practice evacuation drills.
- Irrespective of the extent of fire, call the fire officer.

9. DISCUSSUION AND CONCLUSION

Installation of fire protection systems should be decided based on the fire types and their characteristics. The activities pursued in the buildings must have to be taken into consideration for determining the fire load as well as the extent of fire hazard and accordingly fire suppression system must be recommended in the buildings. As several variables are involved in the phenomenon of fire, an approach of ensuring the fire safe design of a building should be adopted. The qualified and trained fire engineers should be involved in the planning and design stage of buildings to make sure about the incorporation of adequate fire safety measures in the early stage of buildings. This improves the passive fire protection system of buildings.

The building code and standards laid by the government are the minimum requirements expected in design and construction of buildings. This has been employed to protect the occupants and generally it signifies the negotiation between optimum safety and economic feasibility. While installation of firefighting systems, builders and owners can set their requirements above these minimum standards.

Iinstallation of passive fire protection system in existing building requires many alterations, in such cases installation of an active fire protection system is the only option. Hence an active fire protection system has been discussed in detail in this review paper.

Fire suppression system should take the note of all these factors and adopts an integrated systems approach to achieve the optimum results.

Absolute safety from the fire is not achievable in practice. But reasonable degree of safety may be attained in the buildings with the installation of an integrated system of fire protection that includes the best design features of both passive and active fire protection systems.

It is essential to impart an education and training to the personnel to operate the fire situation as well as effectively operate the firefighting installations in the event of fire.

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