

Fire Accidents in Buildings – Case Studies

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Abstract - Fire accident in buildings is a threatening one now a day. These accidents create heavy lives and property losses. To find the reasons, frequency and giving protection to all type of buildings became challenges to the professionals. In this paper four case studies are presented, the reason for fire or ignition source, fire spread, reasons for lives losses, property losses, position of passive, active measures are analyzed; few spot photos are also incorporated. Solutions are given for each case study buildings, the common needed solutions also given to avoid the accidents in future.

Key words: 1. Combustion – Fire, 2. means of egress– Escape routes, 3. Compartmentation – thickness of wall around, 4. Exit width – Door width.

1. INTRODUCTION.

Fire or combustion is the process of burning. It is a chemical reaction initiated by presence of heat energy in which a substance combines with oxygen in the air and the process is accompanied by emission of energy in the form of heat, light and sound. **We know that the continuation of fire needs continuous supply of heat, fuel and oxygen in the buildings.** Therefore we must concentrate about these three factors. The supply of **oxygen** is common and continuous from the atmosphere; Fire Accident is an unplanned or unexpected event in the building environment. The second factor of, **fire causes, or sources of ignition** in buildings are of two types, the first one is human error type fire, and the second one is appliances type fire. The human error type's fires are children playing with matches, rubbish burning, smoking and intentional fire. The appliances types' fires are electrical appliances, gas appliances, other fuel appliances, acetylene and liquefied gas, solid fuel appliances and other specified causes fire. The survey and study reveals that human error types fire are the main causes of fire in the buildings. The modern materialized society all activities depends on fuel consumption and energy utilization based, most of the energy utilization processes are fire based. This fire based activities has become the main source of fire accident in buildings for most of the time. The third factor of **fuel supply** based on the nature, quantity and the arrangement of fire load or the combustible materials, which is stored in side of the building. .The type of fire and its severity, spread depends on the thermal behaviour of the combust materials and the way it is burning. The quantity of fuel expressed in terms of fire load The fire load is calculated by the sum of

calorific value of all combustible materials with the volume of the building. In practice, if the volume of the building is high the fire load is also will high which gives a huge threatening value. The fire load distribution is continuous in the building, the fire will be propagating from one end to the other end of the fire load. From ancient scriptures to till date fire is the earliest source of energy and good friend of humanity, if it is in controllable limit it is applicable for all purposes, but if it exceeds the controllable limit, it will become envious enemy and it will creates heavy lives and property losses in life. **Property loss is the direct consumption of combustible materials by fire flame ,but the lives lose are occurring not only by the fire flame but also by heat, smoke, fumes and other toxic substances which are discussed here.**

1.1 lives losses: The excessive heat during fire accidents will give different level degree of burning, **if the body gets more than 30% of burning wounds the survival possibility will become very less.** Generally Smokes are clouds of small particles, bigger size particles are called dust which is also mixed in the smoke This **smoke will affect the vision, making a person to loss his sense of direction, creating more discomfort, breathing will become difficult. It will close all exits and the escape routes. The possibilities of escape from the building will become impossible. The fumes and the toxic substances are present in the fire zone are in the form of Narcotics and irritants.** The narcotics are carbon dioxide, hydrogen cyanide, benzene, acetone, etc., high concentration of these substances rendering an exposed person to unconscious. At lower concentration these substance will affect the nervous and cardiovascular system and reduce mental and motor function of an exposed person, due to these physical and mental problems, the escape from building become impossible. The irritants are hydrochloric acid or acrolein. **It will prevent escape by affecting the eyes and it is moving in upward direction and damage lungs and causes the subsequent death of victims who have survived the immediate exposure.** These losses are un compensable and un bearable in life.

II. MATERIALS AND METHODS

The following four case studies were done in various parts of India. Among the four, two accidents caused

major lives losses which are considered as pathetic and cruel accidents in India. Analyzing factors are: Building plan, set back, Floors accommodation, ventilation, circulation, construction materials, Ignition, Fire feeding materials, Reasons for fire spread, Reasons for lives losses, Failure aspects in terms of fire safety requirements and other factors also.

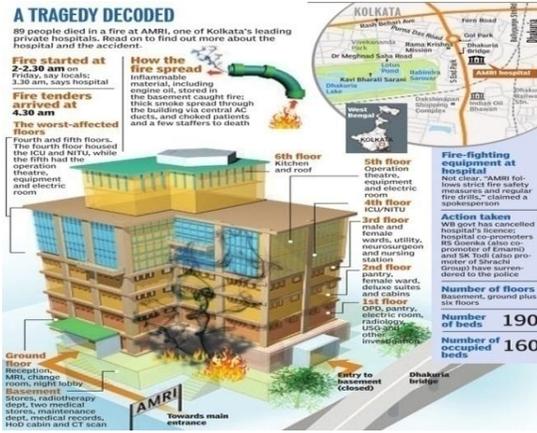
Case study: 1 AMRI Hospital building fire accident.

Date: 9 December 2011. **Place:** Kolkata. **State:** West Bengal.

Lives losses = 94



This photo shows the fire flames and the smoke reaches from basement to all the upper floors (spot photo)



This photo shows the doors, windows and the exterior finishing are constructed by glass material. (spot photo)

The decoding picture explains the hospital location, approachability, number of floors, number of doors, materials used for exterior finish, number of bed, number of admitted patients, fire starting point, reason for high smoke spread and different accommodation.

Ignition of fire: The basement floor used as storage area of diesel, motor oil and wooden furniture store room. Fire started here.

Fire feeding materials: All the floors accommodated with hospital needed common hazard materials

Fire spread: The building having basement, ground + six floors. All doors, windows, exterior finishes are constructed by glass materials. The exterior glasses are not opening or breakable. The fire sprinkler, fire smokers, vent opening on the top are not provided. As soon as the fire started due to combustible materials in all floors thick density of dark coloured smoke, fumes and toxic substances produced, it starts to move basement to upward direction along with the fire flame. Chucking out of smoke from building to outside took four hours after breaking the glasses by the fire professionals. The fire spread was very high in the building.

Reasons for major lives losses: The cubical shape of building without ventilation the fire flame makes the building inside very hot and the smoke covered the entire building and blocked all escape routes. As a patient they cannot make their way out due to suffocation, breathing difficulty, vision obscurity.

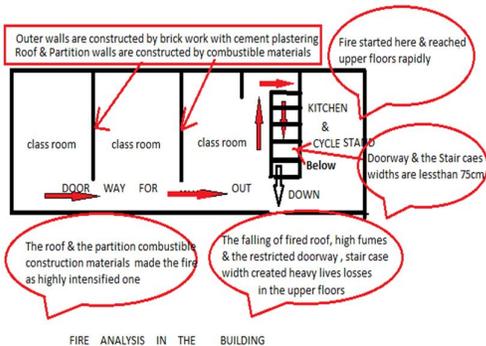
Failure aspects: Provision of minimum requirements of fire fighting appurtenances, housekeeping, security arrangement, disaster management by the management and evacuations procedure.

Solution: If the building might have been provided with proper vent opening and the required fire fighting appurtenances, can reduce the volume of fire and smoke. Or extinguish and chuck out the smoke quickly, can save the lives of patients especially in the upper floors.

Information reached the fire professionals after two hours of burning; the reaching of building took another two hours due to morning traffic. If the information is on time, they might

have reached on time; extinguishment of fire, large number of lives saving might have been done so early.

Case study: 2 Krishna school building fire accidents. Date: 16 July 2004. **Place:** Kumbakonam. **State:** Tamil Nadu. Lives losses = 94



This photo shows the top floor of the building. After consuming the fire the class room partition and the roof. Here there is no door, window, proper ventilation or escape route for each class room.

The building plan explains the different room positions and the accommodations, door and stair case location. It explains where the fire started, speeded, the way it was blocked the routes and arrest the movement of the children and caused the lives losses.

Ignition source: Spark from midday meal kitchen open stove.

Kitchen location: The midday meal kitchen, cycle parking is at the ground floor and the only one stair case is also located nearer to the kitchen.

The first floor and the second floor accommodated with class room for the primary school students. The class rooms are separated by thatched material. **The second floor pitched roof is also covered with thatched material and is continued to cover the kitchen top in the same level.**

Fire spread: Fire Started from midday meals kitchen stove through bamboo pole support to thatched roof and reached upper level of the class rooms rapidly.

Fire feeding materials: Thatched roof, bamboo with coconut coir support, wooden chair table, books, & cloths.

Reasons for large lives losses: The fired thatched roof, class room partition thatched materials with supporting bamboo support fell on the children and blocked their movement, the smoke and consequent scramble blocked the exit routes and the stair case. The children could not make their way out, lot of suffocation children could not breathe out, within few minutes the blaze engulfed the entire floor area. The wooden materials and the note books, and dress materials play an important role for making the fire as a rapid and high intensified one.



This photo shows the unshaped openings in the walls, which were created to take out the corps of the children.

Failure aspects: Provision of minimum requirements of fire fighting appurtenances, water facility, preparedness, knowledge about fire, the passive provision of site set back, escape routes, and disaster management by the staff.

Solution: The building shape is long and linear the school capacity is 900 + staffs. If the buildings might have been provided with another one stair case with adequate number of doors all the children might have been escaped from the building.

If the roofs and the class room partitions are constructed with non combustibles materials with permanent construction the children might not have been arrested in side of the floor and made their way out quickly without any obstruction. **Non combustible materials will have the property that, it will not produce smoke and fumes during fire**

NUMBER OF DOORS NEEDED; (DESIGN)

The number door needed for any building will follow this formula:

$$U = N / (40 \times T)$$

Where N = number of persons

(Floor area / density factor).

T = Time factor in minutes,

U = Number of units required,

Number of exits = (U / 4) + 1

Rate of flow should be 40 persons per minutes for door width.

Case study: 3 Caralton tower office building fire accidents.
Date: 28 February 2010. **Place:** Bangalore. **State:** Karnataka.
Live losses = 12

Ignition sources: The fire was started from basement of the building by an electric short circuit

Fires spread: From basement floor to top floors reached rapidly.

Fire feeding materials: Through the wiring and the electrical fixtures, computers and other furniture materials.

Passive and active measures: Both passive and active provisions are provided properly, but Escape routes are blocked by waste materials, the fire fighting appurtenances are not in working condition.

Reasons for lives losses: Three people jumped from the higher floors. Nine people lost their lives by breathing problem, due to smoke with toxic substances inhale ration.



Photo shows the engulfing smoke and toxic substances from basement to top floor.

Failure aspects: The fire fighting appurtenances are not working, blocking of escape routes and evacuation procedure.

Solution: If fire-retardant material was used in wiring, computers, partitions and other furniture might have avoided the fire ignition. Or if the wiring had replaced by fire resistant wires, even though fire was ignited by short circuit the high fire spread, smoke and the toxic substance might have been avoided.

Blocking of escape routes by the waste materials, closing of fire escape routes and jumping of the staffs from the building failure of precaution for breathing problem's patients, the causes of lives losses, failure of working condition of fire fighting appurtenances shows that lack of fire knowledge and evacuation procedure

Case Study: 4. Saravanastore commercial building fire accident. **Date:** 2 September 2008. **Place:** Chennai. **Sate:** Tamil Nadu. Lives losses = 6

Ignition of fire: Welding fire during mid night in the top most floors.

Fire spread: it is a commercial shop all type of combustible materials are stored in all floors, due to scattering of material continuation fire speeded in all floors.

Fire feeding materials: Paper records, all plastic materials, computer components, wooden furniture, old loose wiring, all electrical kitchen appliances in that floor.

Reason for lives losses: Dumping of combustible materials, heavy fire, thick smoke with toxic substances experienced, being night time all doors were locked out side both top and main entry. No possibility of escaping from the building to out side by the night shift staffs.



Photo shows, heavy fire , thick smoke and emission of toxic substances coming out from building. (spot photo)



Photo shows the fire fighting operation of the professionals, the building having no site setback.(spot photo)

Failure aspects: provision of Minimum requirements fire fighting appurtenances, design of building with escape routes, site set back and approach road to the building.

Solution: Structural alteration required according to the commercial requirements for this building, provision of escape routes in side of the building. The minimum requirements of fire fighting appurtenances should be in the building at the appropriate locations.

11.1.Results and Discussion: All the above four case studies the failure aspects of passive, Active provisions, Reactive procedure are common. Therefore the Passive, Active recommendations are given here for all buildings to avoid accidents in future. (pls. Refer table 1)

III.DESIGN RECOMMENDATIONS

Passive: Passive means it is building plan and design oriented. Any deficiency in the planning and the design will affect the architecture and the construction value of the building during fire. It is not required any energy activation. **If the type of construction and the using construction materials are proper, the building itself or by virtue of its design with construction materials will react with the fire in such a that it will not allow to spreading of fire and its other fire products of heat, smoke toxic substances and fumes from the origination point to adjacent room or other floors or to the other adjacent buildings. At the same time the building having the ability to reduce the size or volume of the fire and its products. The basic elements are: fire door, fire resistant wall, fire damper/ fire seals, compartmentation of wall, means of exits, travel distance, self glowing exists and signage systems.**

Objectives of Passive provisions: 1.Accessibility and reach ability, 2.Containing the fire spread and its products, 3. To

give insulation effects against the fire, heat penetration, 4.to provide sufficient number of means of exits, 5. To enhance the integrity and stability of the building, 6. To provide protected means of escape, 7. To maximize time of safety, actual time require for evacuation

Components: **Building access;** approach road to the building premises, its main entrance gate and its width. Open space around the building to use emergency vehicles such as special ladder and rescue vehicles.

Building material selection and construction: use of non combustible materials, fire resistant treatment by coating or dipping and use less smoke emitting materials,

Building design: well ventilated, provision of explosion vents, designing and dividing big floor area in to small area by providing effective fire barriers walls, so that fire may be contained in the place of origin, which is known as compartmentation, providing enough exits for easy evacuation and natural smoke ventilation provisions,

Building construction fire rating: Using of materials for construction should have **the fire rating of minimum from two hours to maximum four hours.**

Building maintenance: Building should be maintained with good working condition of fire fighting equipments, liberal space provision of life safety requirements and integration of passive safety measure with automatic active fires safety measures.

111.1. Means of Egress Or Escape routes: The escapes routes are to be constructed by high fire rating materials. **Minimum halfen hour to maximum two hours safety time** required for quick easy evacuation during fire.

Low temperature ignition materials, Quick fire spread materials; interior decorative materials are not allowed in escape routes.

Adequate number of doors, corridors are to be provided, all the rooms are to be connected with corridor and all the floors to be connected with stair cases. Head room height minimum should be of 2.4 mtrs. **Ramp ratio should be of 1:8 connected with corridor for physically challenged, childer and elder people.** Two stair cases are to be provided one should be in side and the other one should be facing outside of the buildings. The maximum travel distance from inside of the building to outside should be **30 meters**

The total area of the building is to be sub divided. Safety points or refuge points are to be provided at the appropriate places. Proper illumination level, signage is to be provided. This will help for quick evacuation and safeguard many lives.

111.1.1. Active: These are the external components either temporary or permanently attached with the building and

are activated by external sources of energy at the time of fire in the building. The elements are portable fire extinguishers, Fixed first aid fire fighting equipment like hose reels, fire hydrant installation like wet risers and yard hydrants, manual/automatic fire detectors and alarm systems, fixed automatic fire fighting systems, water sprinklers and emulsifiers systems, co2 fire fighting systems, halon fire fighting systems, mobile fire fighting systems and fire brigades and fire salvage corps.

Objectives of Active provisions: 1. To provide immediate detection and give alarm of fire on its occurrence, 2.to provide immediate suppression effect on fire either automatically or manually on it notice, 3.To prevent the fire spread as well to extinguish the fire at the incipient stage, 4.To reduce the destruction and loss due to fire, 5.To reduce the generation of smoke, fumes from the outbreak of the fire, 6. To minimize time to hazard time required for reaching the maximum level of fire hazard.

Components: First aid extinguishers: to deal with initial stage of fire and to be provided to cover all vulnerable area of the building.

Hose reel assembly system: to deal with small fires to minimize water damage and it should be provided in all floors.

Down comer/ wet riser system: to deal the fire with plenty of water and to be provided with all floors,

Automatic fire detection and fire alarm systems: to detect heat, smoke, fumes and flames to be installed in all appropriate points in all floor of the building.

Automatic water/ water moist or water foam sprinklers system/ gas suppression system: for automatic suppression of fire followed/ simultaneously by automatic detection of fire and to be installed in floors on specific advice of suitability and applicability.

Public address system: To give specific instructions/ information of the occupants, in responding to an emergency and to be provided at all floors with a facility to address either all floors or selective floors at a time

Automatic smoke vents: This mechanism should be provided especially for basements and enclosed part of the building.

Emergency lights, evacuation plan, mock drill and training are vital elements of life safety requirements

Integrated buildings management: It is a the modern feature to control the building by Appling various safer electrical system, which is a essential requirement for campus , multi-storey buildings.

IV. Conclusion

To avoid the fire accidents in the building the passive way of safety design, life safety provisions and the active way of fixing fire fighting appurtenances in the building cannot assure full safety. Number of variables is responsible in the fire phenomenon of the buildings, which are to be identified, assessed as fire hazard. Type of building, the activities going inside of the building, culture, behaviour of the people, maintenance of the building, application of good housekeeping , fire risk management, security management, preparedness, awareness of fire, keeping away the fire sources from the combustible materials, reduction or elimination of combustible materials in side. Using fire retardant materials, Fire proof coated materials or using of impregnated manufactured materials in side are few fire safety parameters, if we adopt these parameters in the buildings,we can avoid the fire accidents and assure the absolute safety of the buildings in future.

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Table: 1 shows the four case studies analysis and inferences

Building Name	AMRI hospital	Krishna school	Caralton tower	Saravana store
Place	Kolkata	Kumbakonam	Banglore	Chennai
No. of floors.	B,G+ 6 floors	G+2	B,G+5	G+4
Type of Function	Hospital	Primary school	Office	Commercial
Ignition source	Diesel and motor oil at basement	Combustible material at ground floor	Electrical fire at basement floor	Welding fire at top floor
Fire feeding materials	Common hazard materials	Combustible materials construction	Electrical wiring, cables, fixture, computers	Electrical, plastic materials with common hazard materials
Type of Fire	Thick smoke fire	Rapid high intensify fire	Heavy smoke, toxic gases emitting fire	Heavy smoke, toxic gases emitting fire
Number of lives losses	94	94	12	6
Failure aspects	Closing of escape routes, failure of working condition of fire Fighting equipments	Failure of passive and active fire safety provisions	Closing of escape routes, failure of working condition of fighting equipments	Failure of passive and active fire safety provisions
Planning	Good	Not suited for school function	Good	Not suited for commercial function
<i>Design commendations: For Future requirements</i>	<i>Minimum Active fire safety requirements</i>	<i>Passive , active fire safety requirements</i>	<i>Minimum Active fire safety requirements</i>	<i>Passive , active fire safety requirements</i>