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Fire Accidents with High Fire Spread in Buildings

KEYWORDS: 1. Combustion – Fire, 2. Fire rating – Safety time 3. Compartmentation –Thickness of wall, 4. Exit width – Door width

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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 of the reasons, frequency and giving protection to all type of buildings became challenges to the professionals. In this paper three case studies are presented, the ignition source, fire spread, reason for lives losses, property losses, position of passive active measures are analyzed, few spot photos also incorporated. Solutions are given for case study buildings, the common needed solutions also given to avoid the accidents with high fire spread in future.*

INTRODUCTION

Fire is the combustion process of burning. It is a chemical reaction initiated by the 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. Therefore three elements are essential for combustion. The one is Combustible substance (fuel), the second one is Oxygen (the gas) and the third one Sources of heat (applied heat). Absence of any of these three will result in extinguishing of the fire. Fire Accident is an unplanned or unexpected event in the building environment.

1.1 Presence of oxygen for continuous fire:

Some materials contain their own oxygen the removal of atmospheric oxygen itself is not sufficient to extinguish the fire. These materials will burn continuously even after removal of the atmospheric oxygen. This is known as chain reaction. There is a small difference in between combustion and ignition. Combustion is an exothermic reaction between a substance and oxygen in which heat is given out in such a manner that maintains the temperature of reactants, thus setting up a chain reaction. In some cases the reaction between a substances and oxygen requires heat to be applied to maintain the reaction and the reaction stops when applied heat is removed. But this is not a combustion process

1.1.1. Presence of Sources of heat for continuous fire:

The causes of fire or sources 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 and gave high fire spread in the buildings.

1.1.1.1.Presence of combustible materials for continuous fire:

The spreading and severity of fire in the buildings is based on the nature, quantity and the arrangement of fire load which is stored in side of the building. The total amount of fire load is not constant on every day sometimes adding up of additional load, sometimes thrown away the waste materials but the reasonable accurate fire load of the building can be calculated by multiplying the weight of all combustible materials by their calorific values with adding the volume of the building. If we dividing the total figure by each floor area will gives the density of the fire load of that particular building. The type of fire depends on the nature and the type of materials and its thermal behavior. If the volume of the building is high the fire load is also very high, it will give major threat. If the distribution of fire load is continuous in the building, the fire will be propagating from one end to the other end..

High fire spread combustible materials in normal fire environment: Combustible substance and oxygen can be in contact with one another without combustion process starting. It will be necessary to apply heat to the mixture before the chemical reaction between the constitution starts, but if once it has started enough heat is given out to maintain or increase the reaction then combustion is said to have started. The combustion process does not always involve the oxygen in the air, two solids, one having combined oxygen in its makeup and then other being combustible, being ready to receive oxygen in to combination, can be mixed together heated up and combustion will take place between the components even if the oxygen of the air is excluded. Such a mixture of combustion are usually violent in this way the high spread is started, sometimes it will become explosive.

2. DEVELOPMENT OF FIRE IN THE BUILDINGS

Development of any fire comprised of four stages. The first one is incipient stage, the second one is growth stage, the third one is fully developed stage and the fourth is decay stage. Flashover is not a stage of development, but simply a rapid transition between the growth and fully developed stages. But in building or an enclosed space the development of fire is consists of three stages only. The first one is ignition and temperature growth, the second one is fully developed fire stage and the third one is decay stage of fire.

Ignition and temperature growth

This stage consists ignition with initial stage of combustion and a fast reaction of fully developed fire. Very little materials are consumed in this stage The temperature of surroundings rises at very high rate. Smoke and heat produced during this stage causes much damage to exposed surfaces and contents of the room. Smoke vapors and fumes producing this stage tend to hamper the escape routes, if such routes are not pressurized, air supply through openings are adequate the smoke with hot gases moves towards upward of the ceiling. These hot gases will prepare the flash over the condition. This is called air controlled burning.

Fully developed fire stage:

All the combustible materials in the building are burning, this

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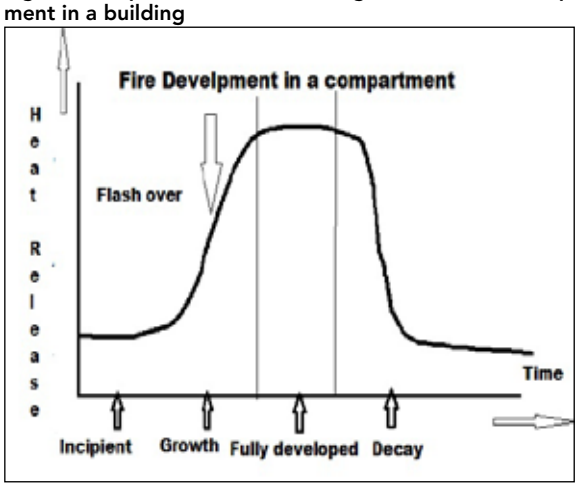
stage the fire is regarded as fully developed. This happens around 500`0C in building fire. During this stage high amount of flaming occurs, lot of heat is produced and major amount of combustible materials are consumed. All the structural elements are subjected to failure, this endangering the collapse of building. It is seen that maximum temperatures reaches in between 900 to 1200`^{0} C in buildings.

Decay stage: This stage large amount of heat, flame, smoke and toxic gases are produced, the transition from fully developed stage to decay stage is rapid and takes a few seconds.

Figure 1. Explains the different stages of Fire - Development in a building



2.1 BEHAVIOUR OF FIRE IN THE BUILDINGS

The following three figures explain spreading of fire inside and outside of the buildings. The fire obeys the principles of Conduction, Convection and Radiation of heat

Figure 2. Fire spread from horizontal position to vertical position BY CONDUCTION in an enclosed space

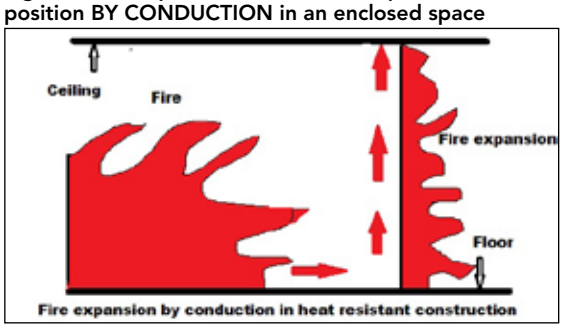


Figure 3. Fire spread from lower floor to upper floor BY CONVECTION currents in the air medium of stair case

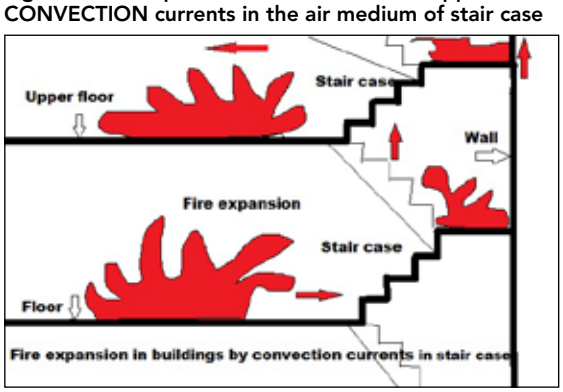


Figure 4. Fire expansion from building no 1`st opening to building no 2`nd of the external surface through air medium BY RADIATION

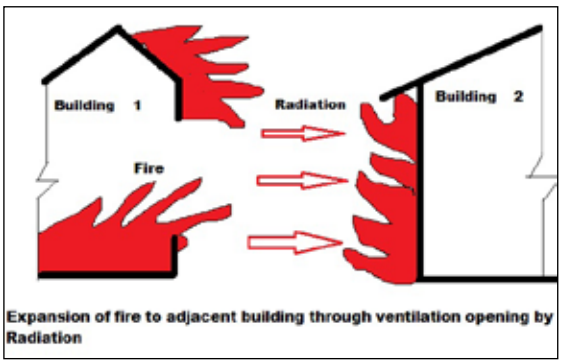


Figure numbers 2, 3 and 4 explains how the fire spreading from its origination point to other room, or to other floor and to other building. It is called the dynamic behavior of the fire.

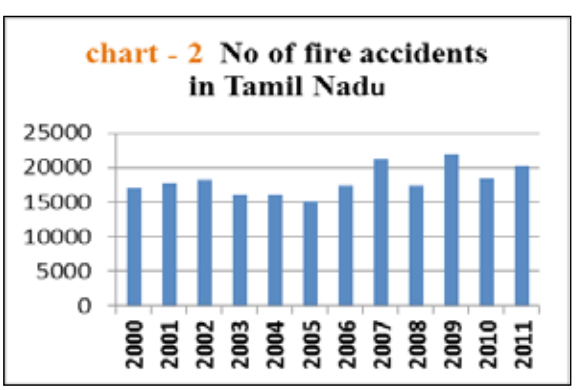
3. MATERIALS AND METHODS: Table: 1

The following table gives the statistical data of number of major, minor fire accidents, in Tamil Nadu from 2000 to 2011 Source: Tamil Nadu Fire cum Rescue Services .

Table: 1

Year	Number of fire accidents
2000	16987
2001	17697
2002	18264
2003	16109
2004	16136
2005	15093
2006	17442
2007	21224
2008	17433
2009	21840
2010	18311
2011	22273
Total 12 years	218809

ANALYSIS: FROM THE STASTISTICAL DATA



Total number of fire accidents = 218809
Average number of fire accidents per year = 18234.08

3.1 RESULTS WITH DISCUSSION:

From the statistical data analysis, the total number of fire accidents, and the average values per year calculated, Graphs are prepared on the year readings.

From the number of fire accidents analysis: The graph columns showing the value of 15000 and above. Every year the number is increasing. The average value is 18234.08 per

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year. It is a huge threatening figure.

Among the number of fire accidents few accidents are considered as high fire spread accidents by the fire professionals. Among that three case studies are presented here.

3.1.1. CASE STUDIES:
CASE STUDY: 1
Building: Krishna School building. Place: Kumbakonam Town. State: Tamil Nadu, Date: 16`th July 2004. Lives losses : 94, third degree burn injured children 18, Age below 10 years.

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 the causes of the fire

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. The kitchen roof is covered with thatched materials and it is joined with second floor roof.

Fire spread: 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 partitions with supporting bamboo support fell on the children and blocked the exit, the smoke and consequent scramble blocked the exit routes and the stair case. The children could not make their way out, within few minutes the blaze engulfed the entire floor area.

Reason for high fire spread: The wooden materials and the note books, and dress materials play an important role for making the fire as a rapid and highly intensified one.

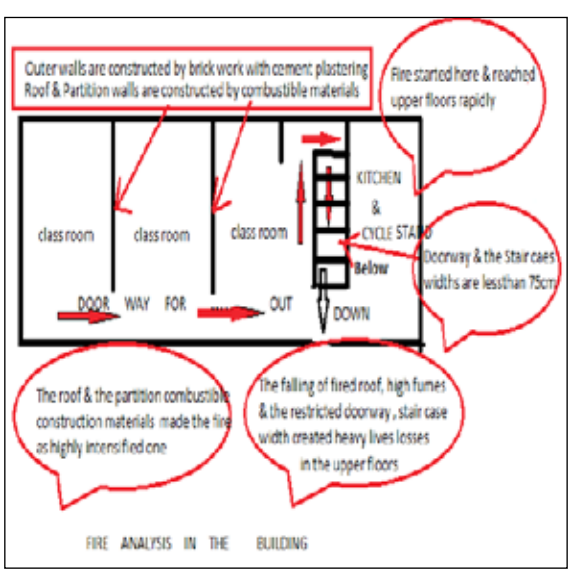

Photo shows the top floor of the building. After consuming the high fire spread in the class room partition and the roof.

CASE STUDY SOLUTION:
The building shape is long linear the school capacity is 900 + staffs.

The building not provided with adequate number of doors, windows or any other ventilation. It was became a confined space.

If the building might have been provided with another one stair case with adequate number of windows, doors, all the children might have been escaped; there were no chances of lives losses

If the roof and the class room partitions are constructed with non combustibles materials with permanent construction, the high fire spread might have not occurred. . Non combustible materials will have the property that it will not produce smoke and fumes during fire even at the high temperature. Even otherwise if the fire occurred it would not be a high spread one.

CASE STUDY: 2. Building:
Padmapriya Marriage hall building. Place: Sri Rangam in Trichi district, State: Tamil Nadu, Date: 24`th January 2004.

Lives losses 57, Third degree burn injured people 50 (women20, children4)

Ignition sources:
Short circuit initiated by a video flash gun.

Location:
Temporary stage provided and covered with lower height roof for wedding celebration. The stage, roof is made up of thatched combustible materials provided in the first floor terrace.

Fire spread:
Spark starts from camera and it catches as fire to lower hanging decorative papers, bamboo poles with Coconut coir helps to reaches the fire to low height thatched roof.

Fire feeding materials:
Decorative papers, bamboo supports, Thatched roof, Plastic chairs, clothes, guest`s belongings.

Reasons for large lives losses: The fired thatched roof fell on the guests, the fired plastic chairs, limited space availability, The Smoke, plastic toxic gases, other scrambles covered and prevented the exit routes and the stair way. The people could not make their way out; within few minutes the feeding fire

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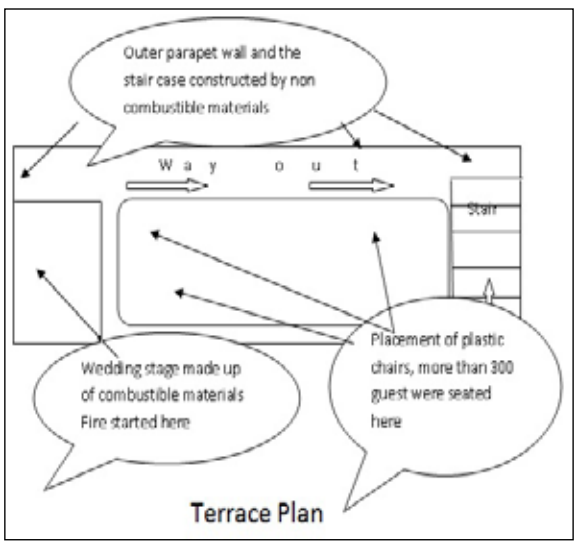
blaze engulfed the entire hall and killed 30 peoples on the spot.

Reasons for high fire spread:
It is a long narrow hall having 75cm wide only one stair case located at one corner. The placement of plastic chairs and the guest`s belongs plays an important role for made the fire as a rapid and high intensified one.



CASE STUDY SOLUTION:
The building shape is long and linear the capacity is 700 guests + staffs.

The lower height roof decorated hanging materials are non combustible materials; the fire might have stopped quickly by starvation of fuel. The placement of plastic chairs might have been avoided, if it is an avoided the proper aisles space for escape might have been provided. During fire the plastic materials will emits heavy smoke with toxic substance

In this case the management has failed to arrange: functional performance system, security arrangement system, proper housekeeping system, keeping stand by water position for expected fire inside and outside of the building with active fire fighting system.

CASE STUDY: 3. Building:
Saravanastore commercial building fire accident. Date: 2`nd September 2008. Place: Chennai. Sate: Tamil Nadu. Lives losses = 6

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

Fire spread:
it is a commercial shop all type of combustible materials is stored in all floors, due to 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.

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

Photo shows live position of high fire spread with thick smoke and emission of toxic substances coming out from building.

CASE STUDY SOLUTION:
The building shape is long and linear in breath wise without the site set back on all four sides. The building not provided with doors, windows or any other ventilation provision. This confined arrangement of building entertains the fire as high fire spread.

The mixer of combustible materials are dumped the whole floor, If the materials are segregated according to its type, the interior other furniture materials should be of fire retardant, the fire spread can be minimized. If the building is designed for commercial purpose with the provision of fire fighting appurtenances the high fire spread can be minimized and extinguished early.

3.1.1.1. CASE STUDIES RESULTS WITH DISCUSSION:
All the above three cases the using of non combustible materials, inadequate provision of windows, doors with stair cases, site set back, failure of providing fire fighting arrangements, housekeeping and security arrangement factors gave main reasons for high fire spread.

4. RECOMMENDATIONS: DESIGN SOLUTION:
PASSIVE SYSTEM:
Buildings are to be designed to serve the particular purpose. a) Proper approach from main road to the building, adequate width of main entry, proper set back according to the zoning and the type of building must be provided. b) Adequate number of doors, windows and two numbers of stair cases are to be provided, one should be inside and the other one should be facing outside of the building for escape purpose. Services facility and the escape routes are to be provided at every 30 mts intervals. C) The maximum travel distance of the building from inside to outside of the building should be 30 mtrs. All the safety parameters are to be applied strictly.d) The building has to be designed and planned very well for good ventilation and circulation, the type of construction should be of high fire rating of non combustible materials. e) The minimum fire rating of two hours to the maximum fire rating of four hours is to be maintained in the building.

Compartmentation:
The compartmentation or the thickness of wall will plays an important roll for stoping the fire spread in the buildings. It has to be provided at 500sq.mtrs or 750sq,mtrs according to the type of buildings. The aim of providing compartmentation in all sides will react with the fire, heat, fumes and the toxic substances, it will not allow it to spread from the origination point to other area, it will have the power to

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reduce the volume of the fire and its spread in the buildings. In these aspects the compartmentation of walls, roofs, and compound wall will prevent the fire spread from room to room on the same floor, one floor to other floor and one building to other building.

Provision of fire doors and the windows will confine an out brake to the smallest possible area and minimize the damage to adjoin property.

4.1 DESIGN SOLUTION:
Active system is the additional one in the building the main objective is to extinguish the fire as soon as it occurrences. Correct selection, installation at appropriate position and its working condition of active system will facilitate to easy and quick extinguishment of fire.

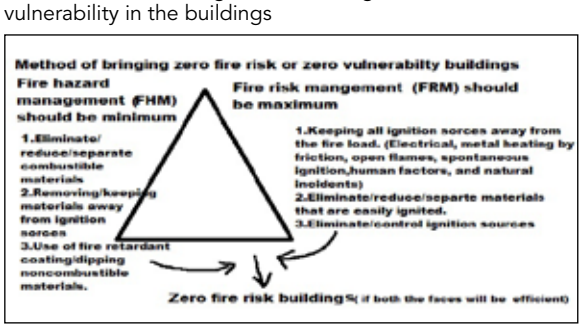
Table : 2 will give the minimum recommendation of essential needed active appurtenance in the building.

Type of building type	External hydrant	Hose reel	Internal hydrant	Water springlar
Residential building	NR	R	R	R
Business building	NR	R	R	R
Industrial buildings	R	R	R	R

Note: NR: NOT REQUIRED, R: REQUIRED

This table is applicable for the buildings having heights up to 15 mtrs

4.1.1. MANAGEMENT OF FIRE LOAD IN THE BUILDINGS:
All the fire protection techniques have to be based onthe thermal behavior characteristics of different combustible materials and the structural element of the building. The activities pursued by the occupants of buildings must also be taken in to consideration for assessing the extent of hazards. This fire load management triangle method will bring zero fire risk or zero vulnerability in the buildings. The figure explains one face of the triangle managing the fire hazard or fire load in the minimum level, the other face of the triangle managing the fire risk in the maximums level, therefore the third face of the triangle will be bring zero fire risk or zero vulnerability in the buildings



We know that, the fire is occurring on the contact of required heat, fuel and oxygen. This basic principle is applied in reverse direction for prevention of fire. The contact of combustible material is separated from the ignition sources for avoiding of fire.

4.1.1.1. OTHER PRACTICAL SOLUTIONS:
The selection and use of furniture and utensils in the buildings will be in any one of the following Impregnation treatment method: Mon Ammoniumphosphate can be applied on each layer of the combustible materials while in manufacturing.

Surface treatment:
Paints applications, noncombustible material`s skim coating in the form of plastering, spraying and trowel led coating will reduce the fire spread rate in the building

Use of composite materials:
The mixture of organic and inorganic materials will become noncombustible. The rate of fire spread will be zero in the buildings

Reduction of fire load management:
Eliminating the fire load or Reduction of fire load. Separating the Combustible materials from fire Source. Use of noncombustible materials, or Low Ignitibility materials, Removing or keeping all the materials away from Electrical sources. Eliminate or Control Ignition sources in the buildings.

5. CONCLUSION:
To avoid the high fire spread 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. The Number of variables is responsible in fire phenomenon of the buildings, which are to be identified, assessed as fire hazard. The practical experience of the fire professional's stat that," Combustible materials are responsible for high fire spread in the buildings". Therefore it has to be managed very well. Type of building, the activities, culture, behavior of the people, maintenance of the building are became important factors in fire. The application of management systems are to be followed strictly in all buildings. If we follow the above said all factors, will avoid the accidents with high fire spread of the buildings in future.

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