Fire Threat in Buildings

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Abstract: ***Fire accident in buildings is a threatening one now a day. The numbers of accidents are increasing in day by day. It creates heavy lives and property losses to the individuals and the nations. To find out the reasons, frequency and giving protection to all type of buildings became challenges to the professionals. A detailed study with analysis required to seek the solution. In this paper the segregation of fire load, the fire load is the main source fire threat and its calculation, the method of fire spread in the buildings are discussed .The last twelve years number of fire accidents, property loss and lives losses are taken as survey. These statistical data are analyzed. The results are discussed. The results demand the proper fire load management to reduce the fire threat and avoid the possibilities of the fire occurrence in the buildings. This paper is concluded with few possible practical solutions to safe guard the building from fire in future.***

Key words: 1. Combustion – Fire, 2. Escape routes – corridor and door, 3. Compartmentation – thickness of wall around,

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. Fire Accident is an unplanned or unexpected event in the building environment. We know that, the fire occurrence and its continuity needs the direct contact of ignition source with fuel and the continuous supply of oxygen. During the fire in the buildings the fuel or the combustible materials plays an important role. These materials distinguish the type of fire. The fire type, its severity, density and its spread depends on the nature, quantity, arrangement of distribution of combustible materials and the way it is burning in the fire**. Based on the thermal behaviour of the materials the fires are classified as 1.Solid fire,2. Liquid fire, 3.Gas fire, 4.Metal fire and 5 Electrical fire. According to the classification the above said fires are extinguished by : 1. Applying water, 2.Smothering atmosphere, 3.Applying gas powder or Vaporising liquid, 4.Application of dry powders and 5. by Electrical dis - connection respectively.** As we all know that fire is one of the basic resource, without fire we cannot live in the modern materialised life, but it should be in the controllable limit for application, when it is exceeds its limits it will causes heavy lose of human casualties, property damage affecting the building, plant and machinery, furniture fittings, electrical equipment and the surrounding environment.

Fire threat is the direct reflection of fire load or the quantity of combustible materials which are stored in side of the buildings. The quantity is expressed in terms of fire load. The fire load is not constant always in the buildings, sometimes additional materials are loaded, and sometimes the waste materials are thrown away, but for the reasonable accurate fire load of the building can be calculated by the following method. If the fire load distribution is continuous the fire propagation will starts from one end to the other end of the load in the buildings.

A. *FIRE LOAD CALCULATION: Fire load is calculated by multiplying the weight of all combustible materials by their calorific values with area or volume of the building. (Calorific value of fuel is defined as the total quantity of heat energy released by the total quantity of materials, after complete burning in the fire). If the fire load value is divided by the floor area will give the density of the fire load on each floor.* The summing up of density fire load of all floors of that particular building will give the total amount of fire load of that building. It is a threat or warning of that building giving to wards to the professionals***. Fire loads are classified based on its quantity. If the fire loads quantity of the building not exceeding 275000kcl/m^2, it is called low fire load building. If the fire loads quantity of the building is exceeding 275000kcl/m^2 but not exceeding 550000kcl/m^2 it is called moderate fire load buildings. If the fire load of the building exceeds 550000kcl/m^2 but not exceeding 1100000kcl/m^2, It is called high fire load building. Residential, Institutional, Educational, Assembly buildings will comes under low fire load buildings type.. Commercial, Factories, Workshop buildings will comes under moderate fire load building***

types. Go downs Storage buildings will comes under high fire load type building types.

B. *CHALLENGES TO THE PROFESSIONALS*: Rapid industrial growth, large migrations towards urban, metropolitan area, limited existence, high cost of land, availability of city in frastructure buying and occupying the building has become grate task in life. Moreover the modern city buildings forms are of high rise and tall developments. The vertical growth of the building is number of times high as compared to its horizontal occupation. It gives a cubical confined space from ground floor to top floor. Large population and valuables are accommodated in all type of occupancies. Multi functioning buildings are also allowed in all places. The designing of building with proper ventilation, circulation, giving services facility to the buildings, Maintenance of buildings, emergency repair works are becoming challenges to all professionals**.**

These buildings are having high fire threat due to its volume **Therefore the provision of life safety, property safety and processes safety measures of the building gains Paramount important.** ***The general classifications of buildings are of Residential, Educational, Institutional, Assembly, Commercial, Industrial, Storage, and Hazardous. Therefore it is a duty or responsibility of the professionals that, we must to assess all hazards in buildings, calculate the fire load and should provide the preventive measures from the beginning to till date.***

II. DEVELPOEMENT OF THE FIRE IN THE BUILDING

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.**

A. 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.

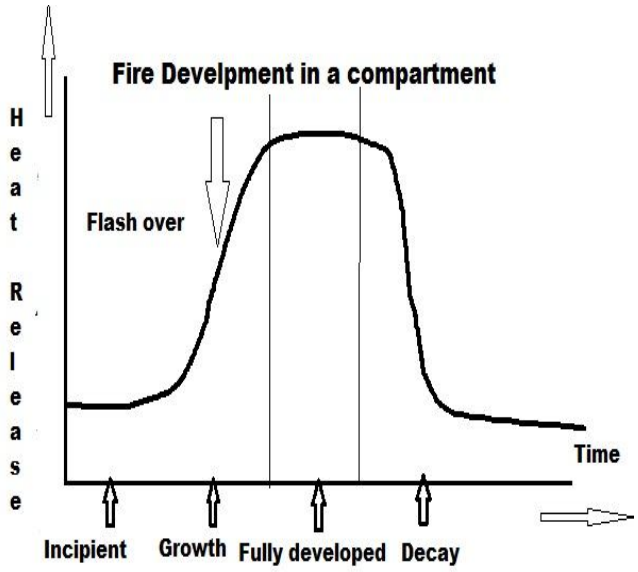
B. *FULLY DEVELOPED FIRE STAGE:*

All the combustible materials in the building are burning, this 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; the collapse of building will take place in between 500`0 C and 600`0 C. If it is a high hazard industrial building the maximum temperatures of building will be 900`0 C. The collapse of the building will be in between 900`0 C to 1200`0 C

C. *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 Explain the Development of Fire in the Buildings



III. 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

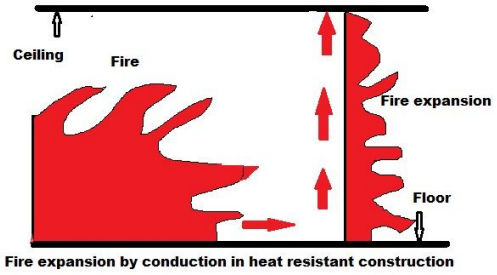


Figure 3. Fire spread from lower floor to upper floor BY CONVECTION currents in the air medium of stair case

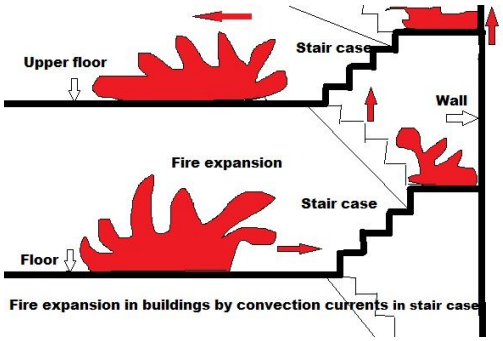


Figure 4. Fire starts from building no:1 and start to spread through its opening to the external surface of the neighbouring building no:2 through air medium BY RADIATION

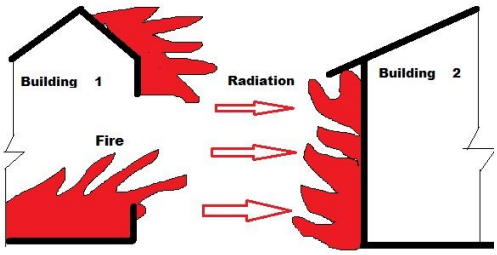
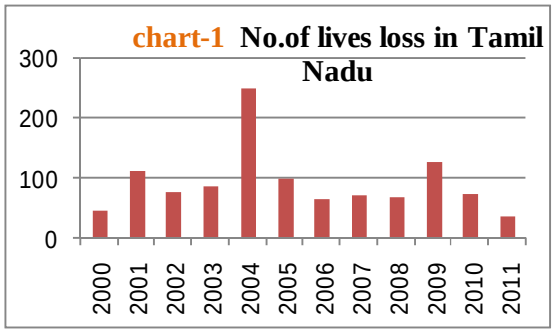


Figure numbers 2, 3 and 4 explains the fire occurrences and spreading from its origination point to other room, or to other floor and to neighbouring building. It is called the dynamic behaviour of the fire.

IV. MATERIALS AND METHODS:

The following ***Table:1*** ***Gives*** *the statistical data of number of major, minor fire accidents, property losses and human lives losses in Tamil Nadu from 2000 to 2011..* ***Source: Tamil Nadu Fire cum Rescue Services***

A. ANALYSIS: *FROM THE STASTISTICAL DATA*:



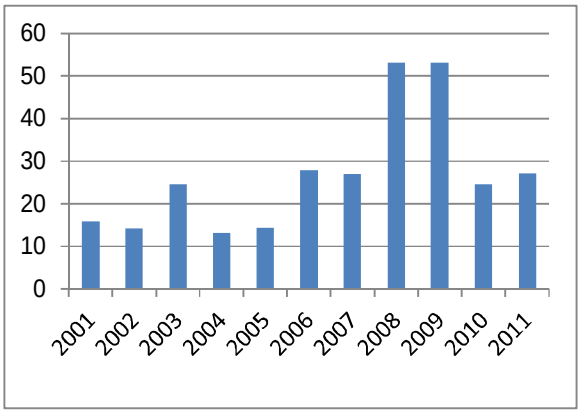
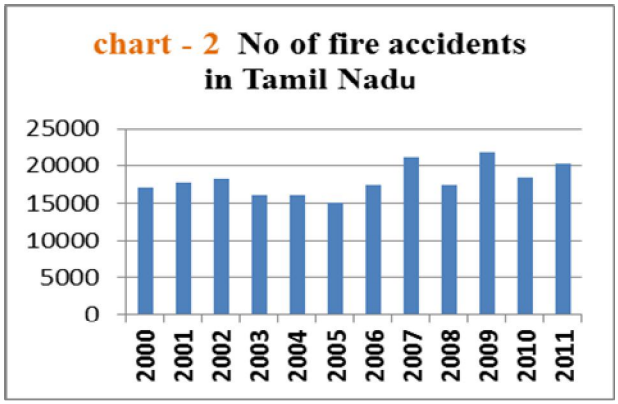


Chart – 2 .No. of Property losses in Tamil Nadu



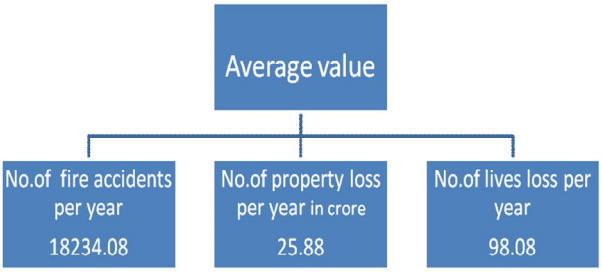


TABLE: 1 SHOWS THE STATISTICAL DATA ***Source: Tamil Nadu Fire cum Rescue Services***

year	Number of fire Accidents	Property loss in crores	Human loss
2000	16987	13.64	47
2001	17697	15.79	112
2002	18264	14.10	79
2003	16109	24.57	89
2004	16136	13.07	249
2005	15093	14.2	99
2006	17442	27.74	65
2007	21224	28.87	72
2008	17433	53.17	69
2009	21840	53.17	127
2010	18311	24.60	75
2011	22273	27.59	84
Total	**218809**	**310.51**	**1177**

B. RESULTS WITH DISCUSSION:

From the statistical data analysis the total number of fire accidents, property loss and lives losses, the average values are calculated. Graphs are prepared on every year reading.

1). *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 year. It is a huge threatening figure*

2) FROM THE PROPERTY LOSS ANALYSIS: The graph columns showing rupees ***19 crore and above.*** *After the year 2005 the amount was vastly increasing. During the years 2008 &2009 the amount reached above 50 crore. The* ***average amount of rupees 25.88 crore per year***

3) FROM THE LIVES LOSS ANALYSIS; The graph columns shows ***above 100 lives loss*** *during the years of 2001, 2004, 2005 & 2009.The* ***average number of live loss is 98.08 per year****. During the year 2004 the column shows above 250 lives losses. This is due the two major cruel, pathetic accidents which are took placed at Kumbakonnam and at Sri rangam in Tamil Nadu state on that year.*

From the introduction part of this article, it clearly explains that the quantity of fire load is directly responsible for fire threat in the building. From the figures 1 to 4 explains the development and expansion of fire from origination point to other part of the building and the neighbouring building, due to the presence of combustible materials and the heat transmission. The statistical data and its analysis of graphs are showing different type of current losses due to fire. Ever year it shows in the incremental value. Therefore it is our responsibility to minimize the fire load of the buildings or giving counter side protection measures against the fire threat. Here few possible practical solutions are recommended for fire load management and passive measures of the buildings.

V.SOLUTION

Fire preventive measures are to be taken according to the types of fire hazard or threat in the buildings. There are three types of fire threat or hazards in the buildings. The first one is ***internal hazard****, the second one is* ***Personal hazard*** *and the third one is* ***Exposure hazards.***

A. SOLUTION FOR THE INTERNAL HAZARD:

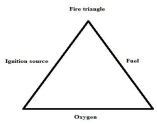
The possibility of fire occurring and spreading inside of the building is referred as internal fire hazard. It is directly connected with the fire load; it causes destruction to the property and the building structure. (Figure 2 & 3 explains the internal fire spread.).

Reduction of fire load, management of fire load and materials treatment will give solution to the internal hazard.

1) *FIRE HAZARD and FIRE RISK MANAGEMENT SYSTEM/METHOD*

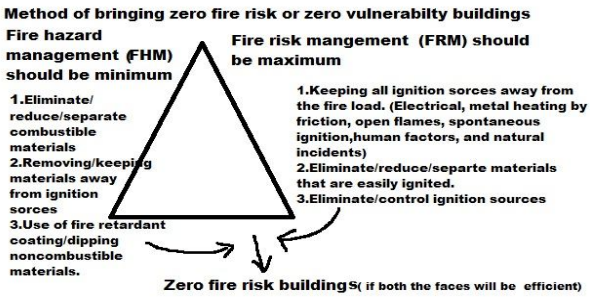
FIRE TRIANGLE**:** The below triangle explains the basic principle of fire occurrence, one face of the triangle having ignition , the second face of the triangle is having fuel and the third face of the triangle is having oxygen when all the three faces are comes in to contact the fire is occurring. This is the basic principle of the fire. The triangle is known as fire triangle.

Figure: 5 shows the Fire triangle.



FIRE PREVENTION TRIANGLE: The fire hazard and fire risk management triangle is working in reversal direction of fire triangle. It prevents the direct contact of fuel and the ignition by wise management. Therefore it is called fire preventive triangle.

Figure: 6 Shows the fire prevention triangle.



The management is by keeping the minimization of fire load in one side of the triangle and maximizing the fire risk management on another side of the triangle. Therefore the third face of the triangle bringing the building under safer zone. The possibility of fire vulnerability is less in the building. This type of maintaining building is called zero fire risk building.

2) *REDUCTION OF FIRE LOAD*; ***Reduction of fire load is achieved by E****liminating the fire load or* ***R****eduction of fire load.* ***S****eparating the Combustible materials from the fire* ***S****ource.* ***U****se of* ***non c****ombustible materials or using of high* ***I****gnitibility materials.* ***Fire risk management is achieved by*** *Removing or* ***k****eeping all the materials away from Electrical sources.* ***E****liminate or* ***C****ontrol* ***I****gnition sources* ***in the buildings.***

3) MATERIAL TREATMENTS METHODS:

The selection and use of furniture and utensils materials in the buildings will be in any one of the following treatment method. This will reduce the fire load and avoid the quick fire spread in the buildings.

IMPREGNATION TREATMENT METHOD: **Mon Ammonium phosphate** can be applied on each layer of the combustible materials while in manufacturing.

SURFACE TREATMENT: **Paints applications**, non combustible material`s **skim coating** in the form of **plastering, spraying** and trowel led **coating** can be applied on the top surfaces**.**

USE OF COMPOSITE MATERIALS: The mixture of organic and inorganic materials will become non combustible, these materials can be used as raw materials while manufacturing.

B. SOLUTION FOR THE PERSONAL HAZARD:

The possibility of fire occurring and spreading causing loss or damage to life is referred as Personal hazard.

Liberal design of escape routes and using construction materials in the interior will give solution for the personal hazard.

1) MEANS OF EGRESS OR ESCAPE ROUTES (CONSTRUCTION AND MATERIALS IN ESCAPE ROUTES): The escapes routes are to be constructed by high fire rating materials. **Minimum half hours to maximum two hours safety time with required wall thickness are** recommended. Low temperature ignition materials, Quick fire spread materials; interior decorative materials are not allowed in escape routes.

2) *ESCAPE ROUTES:* Adequate numbers of doors, corridors are to be provided, All Rooms are to be connected with all with the corridors. All floors are to be connected with corridor with exit and with the stair cases. ***All floors are to be directly connected with emergency stair case.*** To facilitate the physically challenged people, aged people and the children the Ramp should be provided and it should be connected with escape routes by the ratio of **1:8,** two stair cases are required as minimum number, one should be in side and the other one should be facing outside of the buildings. The building has to design that the maximum travel distance from inside to outside of the building should be **30** meters.

3) *SAFETY POINTS*: The total area of the building is 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.

4) CONSTRUCTION AND MATERIALS IN OVER ALL BUILDING: The overall building has to be constructed by high fire rating of the materials with required wall thickness**. The minimum two hours to maximum four hours safety time is required as per its function.**

C. SOLUTION FOR EXPOSURE HAZARD:

The possibility of fire occurring and spreading from starting point to road or to the street or to the neighbouring building through the open air medium causing damage to the building and the neighbouring building is referred as exposure hazard. (figure no: 4 is explaining the exposure hazard)

Using of high fire rating materials for construction and providing required wall thickness in and around site set back will give solution to the exposure hazard.

1) *COMPARTMENTATION:* Required thickness of internal wall and the main wall should be provided. The particular thickness of the wall around an area defines the compartmentation. This area will vary based on the type of building. It means if the compartmentation or the wall thickness will act as a barrier it will not allow the fire, heat, smoke and other toxic substances from the origination point to the other area.

2) *COMPOUND WALL;* Required thickness of compound wall and its height should be provided. It will avoid the

penetration of heat, fire from one building to the other building and act as a fire barrier in between the buildings.

3) SITE SET BACK: The site setbacks of the building should be provided according to the local development regulations. This design provision will avoid the quick fire spread at the same time to facilitate the fire professional to run around the building for fighting operation.

4) *STAIR CASE WIDTH:* The required stair case width has to be provided from bottom to top of the building to facilitate the fighting operation for quick ascending and descending purposes along with the hose reel and other components.

5) MAIN ENTRY: The main entry gate minimum width has to be 4.5meters. The front set back has to be enough for standing the fire fighting vehicle and ambulance while fighting operation..

6) ROAD WIDTH: The street road width,, main road width, Road turning radius width are to be enough for turning the vehicles for reaching the building during fire or any other similar emergency situation

7) GRADING OF BUILDING: The following table explains the grading of building from 1 to 5 based on the fire load and the classification of the fire. The resistance time is achieved by using of non combustible materials with required wall thickness.

Table: 2 Grading of building according to fire rating

Grade	**Safety time/hours**	**Class of fire**	**Fire load in Kcl/m^2**
1	6	Very high	11,00,000and above
2	4	high	500,000to11,00,000
3	2	medium	2,75,000to5,50,000
4	1	low	Less than2,75,000
5	1/2	Very low	Nil

VI. CONCLUSION

Reduction of fire threat or removal of fire threat not only depends on fire load management or the separation of fire load from ignition sources. Other possibilities of fire occurrences are also to be assessed. Safety conscious of the people, behaviour of the people and culture of the people are become important in the concept of fire threat. Along with the above said factors, if we follow the functional performance procedure, the mitigation strategies procedure, proper housekeeping procedure and Maintenance of the building procedure. We can bring the buildings under safer fire zone and assure the buildings in zero percent fire threat in future.

REFERENCES:

[1] National building code of India1983 & 2005

[2] National Fire Protection Association code book,

[3] Chennai Development Control Authority Regulation.

[4] Tamil Nadu Fire & Rescue Services department Rules and regulations

[5] V.K Jain, Fire safety in buildings.

[6] National fire safety council guide.

[7] Relevant Indian government Acts and rules

[8] Fire technology text book, fire safety engineering curriculum.

[9] Press reports,

[10] Fire safety research institute-journals