International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3, Issue No.6, pp : 402-407 01 June 2014

Enhancing Life Safety Provisions in Fire Zones of Buildings

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ABSTRACT: Fire accident in building 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. Fire causes different types of losses but in this paper the lives losses and its passive remedy given importance. The statistical data of twelve years from 2000 to 2012 lives losses has been taken as survey, it is analyzed and the results are discussed. This analysis results directs two case studies which are took placed in Tamil Nadu and considered as major lives losses fire accidents. These case studies concluded with solutions. Fire and lives safety aspects in term of escapes routes design recommendations are given here to improve the lives safety in buildings for future.

Key words: Combustion – Fire, Means of egress–Escape routes, Fire rating – safety time, 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. **The continuation of fire in the buildings needs heat, fuel and oxygen**. These three aspects are to be continuous for fire. The presence of oxygen is supplied by the atmosphere; the second aspect is sources or ignition of fire in the buildings. There are two types of fire ignitions, the first one is human error type fire, and the second one is appliances 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 third aspect is fuel or material supply. The spreading and severity of fire in the buildings is based on the nature, quantity and the arrangement of the combustible materials which are stored inside of the building. Which are expressed in terms of fire load. The fire load is calculated by the sum of all combustible multiplied with its calorific value with the addition of volume of the building. Therefore the volume of the building is high the fire load is also very high. The type of fire depends on the type of materials and the way it is involving in the fire. 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 is exceeds the controllable limit it will become envious enemy and it will creates heavy lives and property loss in the buildings. Lives loses are un compensable and un bearable one in lives. During fire, the lives losses are not only created by the fire flames, but also the fire products of heat, smoke, toxic substances and fumes, these are the prime elements for destroying lives in the fire zones. The detailed explanation of lives losses due to fire and various substances are given here.

1.1 LIVES LOSSES BY FIRE:

Maximum lives losses in the fire accidents are direct burning, the other causes of lives losses may of **heart failure, panic and jumping from higher floors.**

LIVES LOSSES BY HEAT:

Man`s bodies comfort level temperature is 25`0 C, he can manage the temperature rise level in between 25`0 C to 37`0 C. In practical observations, the fire accidents are having above this temperature. The following table gives rise of temperature from 82`0C on wards and relatively the effects of human body when it is exposed directly.

Table: 1 Temperature effects

Temperature	Effects on human body
82	50minutes exposure time
92	33 "
104	26 "
115	24 "
125	Nasal breathing difficult
140	Few minutes tolerance only
150	Mouth breathing difficult
180	Ir - reversible injury within 30 seconds
200 to 300	2 to 3 minutes exposure with wet clothing

The human body gets 30% burns in the accidents the survival chances are very less. The exposure time will vary person to person based on age, gender and body temperature.

LIVES LOSSES DUE TO SMOKE AND DUST: In the fire zones the carbonaceous materials and hydrocarbons materials produce smoke, if it is not burnt properly. Generally Smokes are clouds of particles, each particle will be too small, it will be normally visible by vision but when it is formed as in aggregate

ISSN:2319-6890)(online),2347-5013(print)
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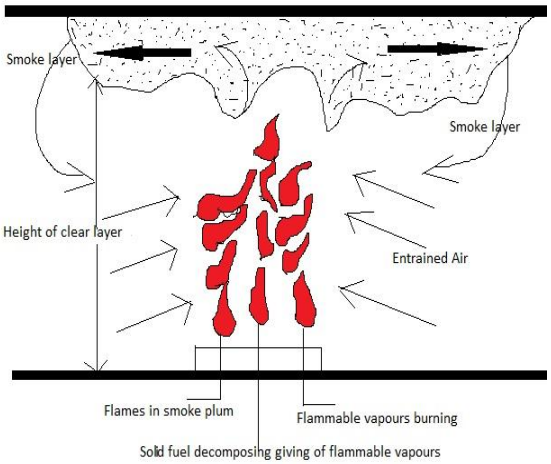
they scatter light and are opaque to visible light The particle size varies but in arbitrary definition, the smoke particle diameter is less than one micrometer and can be suspending in gas. All other particles of sizes more than this dimension are classified as dust. The volume of smoke, its density and its toxicity will depends upon the type of material burning and the way of burning**. This smoke will affect the vision, making a person to loss his sense of direction, creating more discomfort, breathing will become difficult. The possibilities of escape from the building to outside will become impossible.** If it is a high raise building the possibilities of escape will become very, very less percentage for upper floor peoples**.**

1.1.1.BEHAVIOR OF SMOKE IN THE BUILDING: The density and toxicity of smoke may depends upon the nature and thermal behavior of material under fire, but total quantity of smoke will depend on the size of fire and prevalent atmosphere. The figure below explains the solid material fire, the flame contains gases evolved by the decomposing fuel which attracts and entertains the surrounding air, due to its hot temperature and low density of substance in it. The flame, hot gases, excess heated air are mixed with hot smoke and became in separable component of the smoke. This Smoke tend to rise upward of the building up to ceiling, after touches the ceiling its gets spreading in a reversed conical form in the ceiling area and expanding itself by volume horizontally as well as vertically.

When it is reaches the ceiling height it movements is obstructed by ceiling and its starts to disperses in reverse direction to expands and occupying the entire room. **Closing all escape routes and exits. It will become the main reason for major lives losses**. **Figure: 1 Pollution of Smoke and dust in Fire zone and its Behavior in Buildings**



LIVES LOSSES BY TOXIC GASES AND VAPOURS: The most toxic products identified in the fire atmospheres are: 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 in side to outside 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. The following table gives toxic compounds which may be produced by combustion of various materials **Table: 2 Toxic, vapors compound materials**

Toxic gas or Vapors	**Source of Materials**
Carbon dioxide &monoxide	All combustible carbon materials
Nitrogen oxide	Celluloid polyurethanes
Hydrogen cyanide	Wool, silk, leather, cellulosic plastics and
Acrolein	Wood , paper
Sulphur dioxide	Rubber, Thiokol's
Halogenated acids	Polyvinyl chloride, retardant, fluoriated plastics
Ammonia	Melamine ,nylon ,urea formaldehyde resins
Aldehydes	Phenol formaldehyde, wood, nylon, polyester
Benzene	Polystyrene
Azo-bis-succino-nitrite	Foamed plastics
Antimony compound	Fire retardant plastics
Isocyanates	Polyuthrethane foms

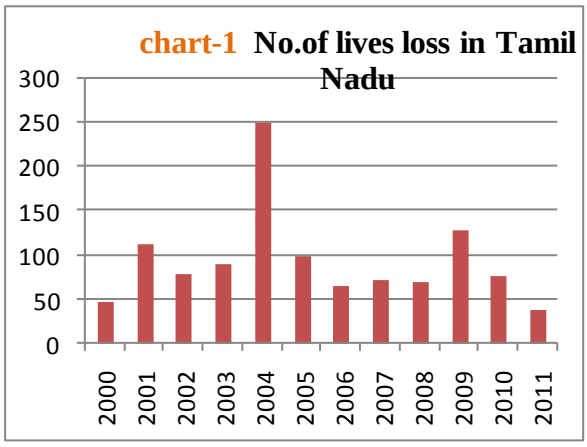
LIVES LOSSES DURING FIRE BY OTHER CAUSES: People are not awake, delayed awareness of the fires, Exists locked or barred or blocked, Collapse of the escape routes, the escape routes are not properly known or too lengthy or Alternative escape routes are not known. Escape routes are closed by smoke or obstructed by in heavy fire, Too much of the persons trying to get out simultaneously, but the capacity of escape route is limited.

II. MATERIALS AND METHODS: The following **table: 3** gives the statistical data of number of major, minor fire accidents, property losses and human lives losses in Tamil Nadu

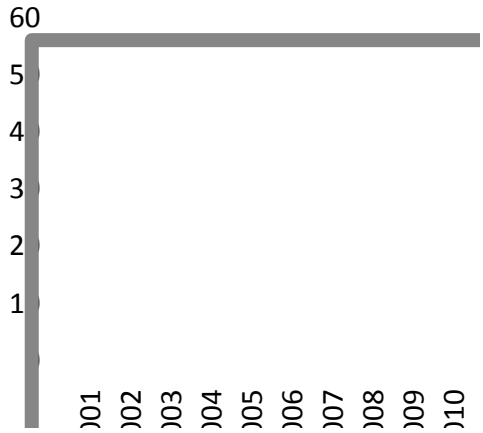
ISSN:2319-6890)(online),2347-5013(print)
01 June 2014

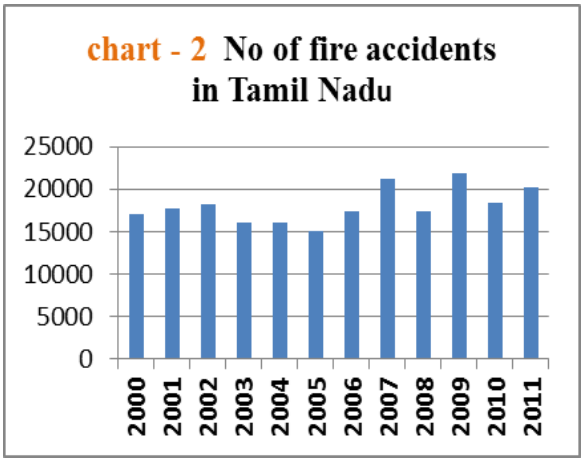
from 2000 to 2011.***Source: Tamil Nadu Fire cum Rescue Services***

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**



ANALYSIS: FROM THE STASTISTICAL DATA





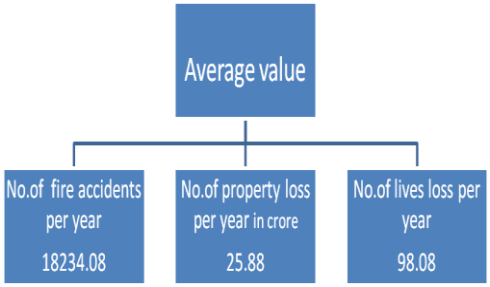


Chart -3: No.of property loss in Tamil Nadu **Chart 4: Average value per year**

2.1 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.

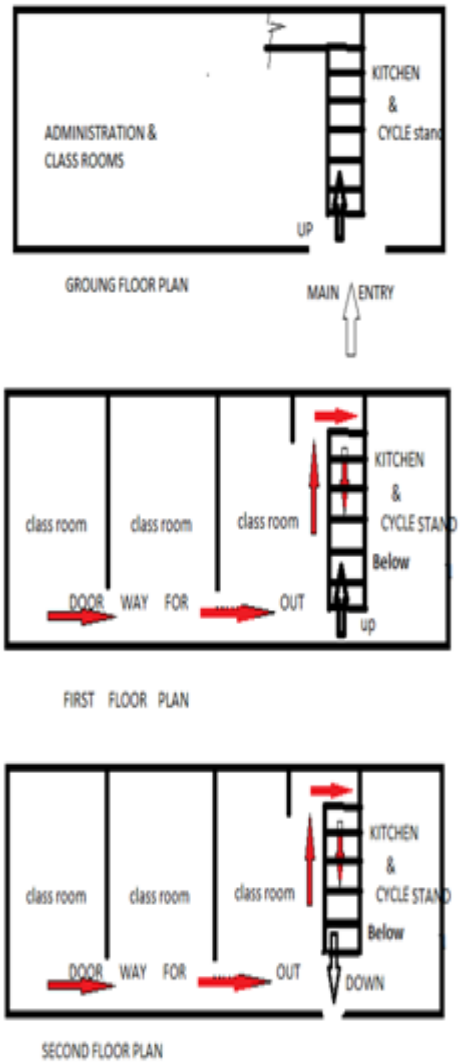
From the number of fire accidents analysis: The graph columns showing the value of 15000 and above. Every year

ISSN:2319-6890)(online),2347-5013(print)
01 June 2014

the number is increasing. The average value is 18234.08 per year. It is a huge threatening figure

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

CASE STUDY NO: 1 Krishna School building fire accidents. Place**:** Kumbakonam Town, **State:** Tamil Nadu, **Date:** 16th July 2004. Lives losses **94,** third degree burn injured children **18, Age below 10 years.**



The building plans explain 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 the lives losses.

Ignition source: Spark from midday meal kitchen open stove.

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 accidents which are happened at Kumbakonnam and at Srirangam in Tamil Nadu state on that year. Both these two cases are taken as case study.

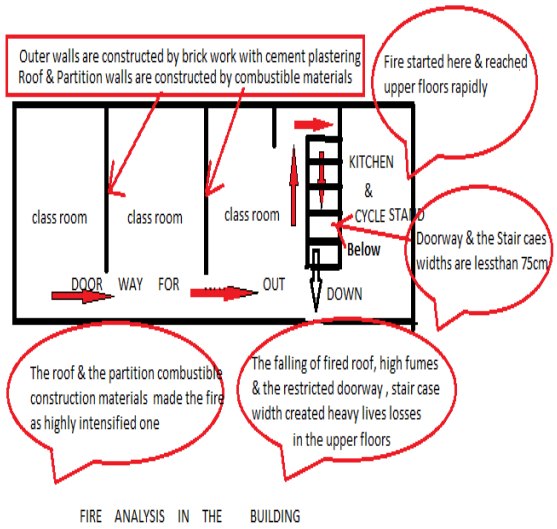
Kitchen location: The midday meal kitchen, cycle parking is at the ground floor and the only one stair case is also located nearer to the kitchen.

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 covered with thatched material and extended to cover the kitchen top at the same level.

Fire spread: Started from midday meals kitchen stove through bamboo pole support to the thatched roof at the second floor reached 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 plays an important role for making the fire as a rapid and intensified one.



FIRE ANALYSIS IN THE BUILDING

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

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

This Photo showing the class room position after burning

CASE STUDY NO: 2. Padmapriya Marriage hall fire accidents. **Town:** Sri Rangam in Trichy district, **State**: Tamil Nadu, **Date:** 24th January 2004.**Lives losses 57, Third degree burn injured people 50 (women20, children4)**

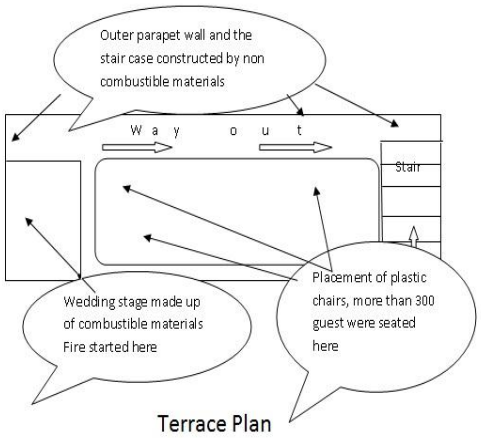
Ignition sources: Short circuit initiated by a video flash gun. **Location:** Temporary stage provided and covered with lower height roof for wedding celebration. The stage, roof is made up of thatched combustible materials provided in the first floor terrace.

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

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.



Terrace Plan

2.1.1. ***CASE STUDY SOLUTION:*** **Both the cases:** the building shapes are long and linear the school capacity is 900 + staffs, the marriage hall capacity is 700 guests + staffs. If both the buildings might have been provided with another one stair case, with adequate number of doors: all the children from the school building and the entire guest in the marriage hall might have been escaped. There were no chances of lives losses.

School building: If the class room partition and the roof are constructed with non combustibles materials with permanent construction the children in the first and the second floors might not arrested in side made their way out without any obstructions. **Non combustible materials will have the**

property that it will not produce smoke and fumes during fire.

Failure aspects: Preparedness, the basic knowledge about fire, reaction with fire, provision of minimum requirements of fire fighting apparatuses in the building and site set back.

Marriage hall building: The temporary structure of low roofed thatched roof might have been avoided, or if it is un avoidable, proper water facility with security arrangement might have been done by the management, or instead of thatched material some other composite materials might have been used.

Failure aspects: Housekeeping, security management, risk management, functional performance management, the provision of minimum requirements of fire fighting apparatuses, site set back and fire reaction of the guest.

III. DESIGN RECOMMENDATION IN ESCAPE ROUTES: The escapes routes are to be constructed by high fire rating materials. **M**inimum two hours to maximum four hours safety is required. **L**ow temperature ignition materials, Quick fire spread materials; interior decorative materials are not allowed in escape routes. **A**dequate width of corridor has to be provided based on the capacity. **A**ll the rooms in a floor are to be connected with the corridor; all the floors are to be connected with stair cases and the ramp. **T**he minimum head room height of the corridor has to be 2.4 meters. **T**wo stair cases are to be provided in all types of buildings, one should be provided in side, another one should be provided in such a way that it should facing the outside of the buildings. **T**he ramp should be connected with escape routes in the ratio of **1:8** for physically challenged people. **T**he escape routes are to be provided at every **30** meters intervals of the building. **T**herefore the maximum travel distance from any point of the building to outside of the building should be **30** meters. **T**he total area of the building is sub divided, Safety points or refuge points are to be provided at the appropriate places. **P**roper illumination level, sign ages are to be provided in the exits and the escape routes. This will help for quick evacuation.

111.1.DESIGN OF DOOR WIDTH:

Adequate numbers of doors are to be provided with adequate width and should be located in required places.

The door width required for a single persons to travel through in it is **= 500 mm: W**idth required for **2** persons (500 +500) = **1000mm**: **W**idth required for **3** persons (500 +500+250) = **1250 mm: W**idth required for **4** persons (500+500+250+250) = **1500 mm:**

Rate of flow should be 40 persons per minutes per unit available.

111.1.1.NUMBER OF DOORS NEEDED; The formula is **U = N / (40 x 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.**

IV. CONCLUSION: Liberal designs of escape routes are helping the occupants for smooth and quick evacuation. It is a basic provision of each building **it will increase the safety time**. Along with this provision, the other requirements of self preparedness, alertness, response practical training is become needed or essential requirement now a day. Functional performance procedure, mitigation procedure, risk management procedure and good housekeeping procedure are should become mandatory in the public buildings. If we follow the all above said factors it will assure total lives safety in all types of buildings.

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