A Thesis on

EVALUATION OF FIRE SAFETY NORMS IN RESIDENTIAL BUILDING

Submitted for partial fulfillment of award of

MASTER OF TECHNOLOGY

Degree in

CONSTRUCTION TECHNOLOGY & MANAGEMENT

By

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DECLARATION

I declare that the research thesis entitled **"Evaluation of fire safety norms in residential building"** is the bonafide research work carried out by me, under the guidance of **Mr. Anwar Ahmad Asst. Professor, Department of Civil Engineering, Integral University, Lucknow.** Further I declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diplomas, and has not been submitted anywhere else.

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CERTIFICATE

Certified that the thesis entitled **"Evaluation of fire safety norms in residential building"** is being submitted by **Mr. Mohammad Affan (Roll no. 1801103007)** in partial fulfillment of the requirement for the award of degree of Master of Technology (Construction Technology and Management) of Integral University, Lucknow, is a record of candidate's own work carried out by him/her under my supervision and guidance.

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree or diploma.

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CHAPTER-1

INTRODUCTION

1.1. Introduction

India is the country situated in South Asia. India is the sixth-largest growing economy in the world and the major portion of GDP comes from agriculture. After agriculture, the construction industry contributes maximum in the GDP (near about 6.2% in 2005 – 2006 and 19% in 2011 – 2012 and 13% in 2015 – 2016). The construction industry employs 35 million people and has an annual turnover of US$ 445 billion. *[web1][web2]*

Fire is a frequently occurring disaster that may be caused by nature, humans, and/or both. Fire leads to fatalities and also material loss. Also besides, it may damage the environment, facilities and infrastructures, public facilities, and may also create disturbance in the society's life and livelihood. This study aims to evaluate the implementation of fire safety measures in residential building.

Fire poses a major threat to various occupancies in India. Almost every day some fires are reported by media across the country. These fires not only resulted in the loss of many precious life and injuries to many but also inflicted heavy property loss.

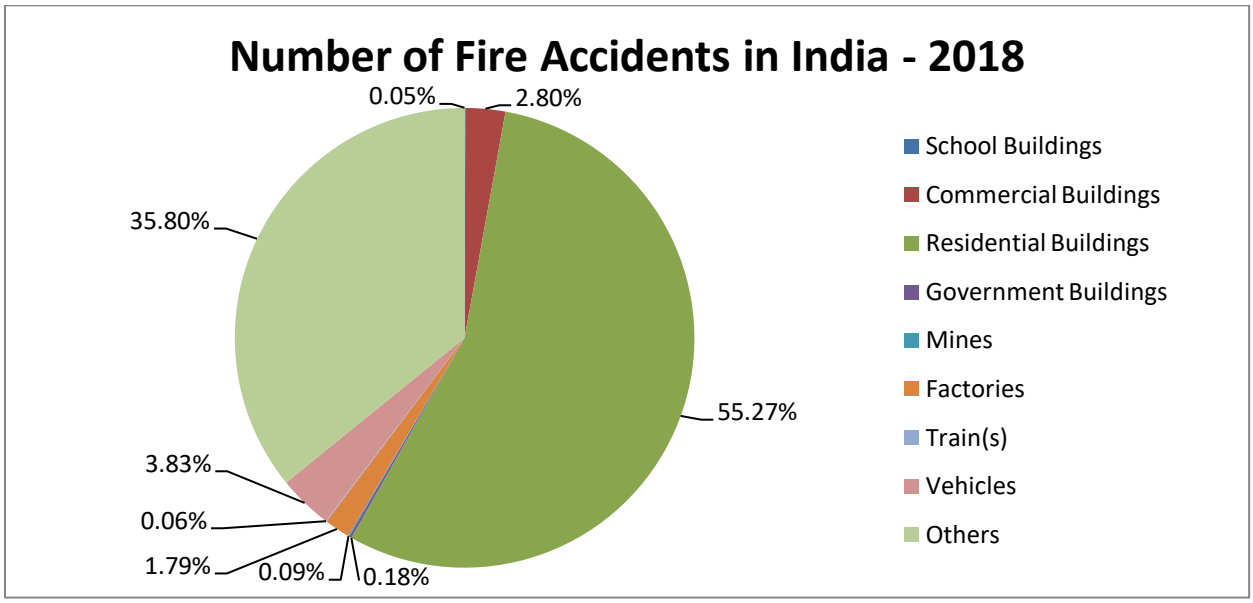

Fig.1: National Crime Records Bureau **(**Ministry of Home Affairs) 2018

During the last two decades there was a vibrant growth in the construction activities in India, especially in high rise buildings. Because of its peculiar nature, fire in residential buildings, in particular, high rise buildings become more complex and the salvaging operations become more difficult and sometimes even resulting in many deaths and huge property losses. The rapid modernizations of Indian Industry have made the scenario more complex. Awareness towards fire safety had not been quite forthcoming.

The purpose of this paper is to focus on the overall scenario on the existing fire safety regulations in India and the effectiveness of these regulations for combating the potential fire hazards.

1.1.1. **Theoretical review**

Fire safety can be defined as the set of practices to prevent or avert occurrence of fire and manage growth and effects of accidental or intentional fires while keeping resulting losses to an acceptable level. Fire is an unwanted event and, sometimes, out of control. The theory that describes the process of fire is referred to as the *fire triangle theory*. This theory describes three factors that react to one another to create fire. Without one of the elements, fire will not happen. The three elements of fire are fuel, which consists of combustible solid, liquid, or gas materials that are mixed with the oxygen in the air, such as wood, paper, or benzene compound. Heat source, which is an energy that is adequate for igniting the mixture between fuel and oxygen in the air and trigger fire, such as hot surface, electric devices, or static electricity. Oxygen: both in the air or as an oxidized compound. However, with the advances in science, a fourth element of fire is found, which is referred to the chemical reaction chain. This chemical reaction chain sustains fire. *[web3]*

The four fire elements are often referred to as the *fire tetrahedron*. Fire load is a value that relates to the amount of goods or materials in a combustible building/room. Fire load is the level of heat contained by the material. A fire load of a building is classified into two: fixed fire load and movable fire load. Fixed fire load is caused by the amount of structural materials that can be burnt such as walls and floors. Meanwhile, the movable fire load is caused by the content of the building such as furniture and decoration. Hence, the fire load for a building will be varied according to its function, which influences the content of the building.

The characteristics of materials that can become fuel in a fire, which increase potential fire in the building, include the goods or equipment placed on the floors that is used as a storage for most material such as motor oil product, paint, and gasoline that are categorized as combustible materials. In addition, there are also other materials in the building such as wood; and gypsum boards that are used as the compartment dividers that can also become fuels during fire. Buildings under construction or renovation are at their most vulnerable and weakest condition, accumulation of waste combustibles, limited access, minimal water supply, and hazardous operations increase the challenge.

The buildings above 15 meters are called as high-rise buildings that are in the form of malls, hospital, apartments, and multiplexes. Unfortunately, some major accidents had taken place in such buildings which are whistleblowers to stand for the accident-free environment. To ensure safety, the Government has provided provision to armor with the latest Right to Information rules. There are also amendments in the factories act 1948 that prescribes provisions related to the hazardous process. Accordingly, all types of high-rise buildings should have Fire Clearance Certificate or FIRE NOC.

FIRE NOC or Fire clearance certificate is a No Objection Certificate indicating that the building is designed as per the norms and regulations that a high-rise building must have to avoid any hazardous accidents. It is issued by the Fire department of the respective state before the building construction. The Building authority applies to the FIRE NOC before the construction with enclosing the appropriate building plan. The building plan should have complete details, including structure, a design of the staircase, electrical power supply, lift design, open space, Fire exit, raw material, design and additionally it should have provision for:

- Fire safety measures, Fire extinguishers and Fire evacuation measures that are going to be incorporated in the building.
- Minimizing the spread and intensity of Fire within the building and any other building.
- Controlling the generation or spread of smoke to the possible extent.
- The implementation of the device that can detect the Fire and can warn the occupants or user.
- Immediate access to the device to control the rising Fire.
- The design should be designed by the registered architect.

Fire safety essentially consists of two aspects. That is fire resistant construction and ability to control fires in case of occurrence. Many countries have developed many useful techniques for the above and adaptation of a desirable and cost effective fire safety enhancement solution will be highly desirable for the future buildings.

Violation of fire safety norms is one of the major causes of fire accidents in India. Every building in India needs to comply with the state guidelines. Many states adopt The National Building Code (NBC). Hence, fire safety rules are different in every state.

Violation of safety norms has a serious impact as the country is overpopulated and a fire accident could lead to many fatalities. Fires also damage livelihoods most often and so in a sense can destroy years of having built a business or enterprise. In our country, unfortunately finding loopholes is easier than compliance. There is a laxity in every level, not just the authorities but also the general public who do not take fire safety seriously.

The fire resistivity quality and properties of concrete performing at elevated temperature have been improved through cement replacement with certain percentages of pozzolana**.**

1.1.2. **Fire Risks During Construction**

Causes of fire during the construction process

1. **Hot work.** Hot work operations pose a significant risk because they can introduce ignition sources into many areas of the worksite. Even many hours after welding, soldering, grinding or other hot work has been completed; a spark can smolder and ignite combustibles, sometimes after crews have left for the evening. Implementing a hot work permit system, with a dedicated fire watch, a minimum 30-minute cool-down period, and assigning fire prevention Program Manager to oversee operations can help avoid fires.

2. **Temporary heaters.** All temporary heaters should be UL Listed and used by the manufacturer's instructions. Maintain safe distances from combustible materials and never allow others to bring temporary heaters onto job sites without approval. Heaters should be monitored by employees or security guards for safe operation during use.

3. **Arson.** Unsecured construction sites may be at risk of vandalism, theft, and arson. Having a layered approach to security, including perimeter controls, fencing, lighting,

electronic intrusion detection systems, and security guards on duty after hours, can help reduce the risk of unauthorized entry to the site.

4. **Smoking.** Smoking presents a serious fire risk to any construction site. A strict "no smoking" policy that is communicated to all employees and subcontractors, and providing a designated safe smoking area, help prevent the risks of fire due to ash or carelessly discarded cigarettes.

5. **Flammable and combustible materials.** All flammable and combustible liquids and gases should be used and stored so that they do not present a fire hazard to the site. Limit the amount of flammable and combustible materials inside the building under construction and designate safe storage locations.

6. **Cooking.** While having a break area on-site is acceptable, workers should not be allowed to bring any cooking equipment, such as grills, hot plates, or small microwave ovens, to the construction site.

7. **Temporary electrical and lighting**. All temporary electrical service lighting should be installed by National Electric Code standards. Systems and lighting should be maintained and regularly inspected by the electrical contractor.

8. **Rechargeable-lithium ion batteries.** Cordless tools and other battery-run equipment present risks of overheating and igniting fires. Charging stations should be outside the building under construction and stored in a safe location.

9. **Lack of fire protection.** Until fire sprinklers are activated, having fire extinguishers distributed throughout the site, standpipes for firefighting equipment and identified proximity to fire hydrants closest to the worksite, can also help firefighters contain fires and minimize damage. Where provided, automatic sprinklers should be activated as soon as practical as construction progresses.

1.1.3. **Prevention from the fire in high-rise buildings**

1. **Fire safety system** – A fire safety system like a fire extinguisher, smoke alarms, sprinklers, hydrants, etc, ensures that a building has all the essential resource that is helpful in case of a fire accident. As mentioned earlier, high-rise buildings are more challenging and firefighting becomes complicated. Hence, a building equipped with

firefighting like automatic sprinklers helps to curb a fire before a firefighter could reach from outside.

2. **Evacuation Challenges**: In high-rise buildings evacuation also consumes a lot of time as the inmates have to be brought to safe areas slowly and through fire exits and stairways

3. **Compliance with fire safety laws** – Fire safety rules are designed to protect people and property. It also helps us to identify the potential hazards and eliminate them with the help of safety measures.

4. **Fire drills** – Fire drills help us to be prepared and educate every individual of their responsibility. Fire drills are also very important to ensure that the occupants are familiar with the sound of the smoke alarm, the numbers to dial and exit routes.

5. **Regular inspection & safety audit** – Fire safety does not end with installing fire safety equipment, there has to be a regular inspection. The inspection should be carried out by the fire department or authorities in every jurisdiction. Surprise inspections by the authorities are also the best way to ensure safety at all times. Having said that, it is also the role of every association or owners to ensure thorough maintenance of fire safety equipment in their community.

6. **Clear exit paths and safe assembly point** – The exit paths of a building must be marked and always clutter-free. There should be a safe assembly/meeting point outside the building.

1.1.4. General Fire Precautions

- To reduce the risk of fire and fire spread
- In relation to the Means of Escape (MoE) from the premises
- For ensuring that the MoE can be safely and effectively used at all material times
- In relation to fire fighting on the premises
- In relation to detecting and giving warning in case of fire
- In relation to emergency action to be taken in the event of fire, including training and mitigating the effects of fire

1.1.5. **Components of Fire**

A combination of heat, fuel and oxygen can result in the ignition of an accidental fire. This commonly called the Fire Triangle. In the view of containing fires, the most important method is to prevent the meeting of the three elements of fire. If the meeting can't avoid, the environment should be controlled well to prevent their interaction or mechanism of action. In the terms of avoiding and decreasing the loss of building fires, the exposure of life and property in time and space should be controlled firstly, and then the disaster inducement factors in the fire process should be limited.

All employees should be conducing continuous assessment of these elements of fire by trying to keep sources of ignition isolated from sources of fuel. This is very important in the prevention of fire. It is important to identify them as such:

A Source of Heat:

- Smoking Materials e.g., cigarettes, cigars, matches, or lighters
- Cooking
- Open flames
- Electrical equipment
- Light fixtures
- Heat and sparks from grinding and cutting metal
- Arson

A Source of Fuel:

- Combustible refuse and trash
- Building materials
- Flammable gases
- Flammable liquids
- Packaging materials

A Source of Oxygen:

- Normal atmosphere is 21% oxygen
- Additional sources of oxidizers

There are 12 parameters of safety that can be used to assess safety in a building:

construction, danger segregation, vertical opening, sprinkler, fire alarm system, smoke detection, interior finish, smoke control, exit access, evacuation path, corridor or compartment, and emergency response training.

With the limitation of a human body to endure fire, a method to estimate the condition when there is a fire in the vicinity is needed. One method that can be applied to do evaluation on the fire safety level of a residential building is by doing simulation.

There are several models that are used for calculations in fire simulation, such as for predicting the temperature of the room when it is on fire, smoke growth rate, gas produced by combustion. Such models include zone model and CFD (Computational Fluid Dynamic)/field model.

The Fire Risk Method (FRIM) is a method for evaluating fire danger that is frequently used in Nordic countries. The Fire Risk Method (FRIM) can be applied easily without requiring in-depth knowledge on fire safety. However, building structure should be known, such as building plan, building materials, and ventilation system design. The Fire Risk Method (FRIM) can be used for multi-story buildings such as apartment.

A high index value shows a high fire safety value and, on the contrary, a low fire safety score shows a low fire safety value. In FRIM, there are 17 parameters that become the indicators of fire safety of a building, including the walls, rooms, fire extinguishing system, fire extinguishing services, compartment arrangement, structural separation, doors, windows, outside part of the building, attic, surrounding buildings, smoke control system, signal system, escape route, structure load, maintenance/information, ventilation system.

1.1.6. References

1. Web2:https://en.wikipedia.org/wiki/Economy_of_India#cite_note-WTTCBenchmark-174

2. Web2: http://statisticstimes.com/economy/sectorwise-gdp-contribution-of-india.php

3. Web3: https://knepublishing.com/index.php/Kne-Life/article/view/2571/5513

4. Code1: NFPA 101A: *Alternative Approaches to Life Safety* and NFPA 101: *Life Safety Code* standards.

5. Code2: National Crime Record Bureau, NCRB, I. (2019). CHAPTER – 1 ACCIDENTS IN INDIA Introduction the comprehensive revision of the proformae Suicides in India ' completed in 2014 in consultation with States / UTs Police and deaths that could be due to forces / factors of the nature which have been termed as. *Accidental Deaths & Suicides in India 2018*, *Chapter-1*, 1–13.

1.2. Objective

- To determine the cause of fire in residential building.
- To increase the visibility and minimize the evacuation time in high rise residential building.
- Develop practices and procedures to reduce fire risk.

1.3. Scope

- Study area will be limited to fire safety in residential building in Indian scenario only.
- It will not include any other safety assessment.

CHAPTER-2

LITERATURE REVIEW

2.1. Introduction

The all literature was searched from authentic journals and conferences from the online library database Integral University Lucknow, science direct, Research Gate, Knowledge E, Shodhganga, Core and various other relevant sources. In starting, generally web searched is done by using some common keywords like ―Fire Safety‖, ―Fire in Residential Buildings‖, Fire in High-rise buildings‖, ―Prevention of Fire‖, ―Causes of Fire‖, ―Fire Safety Guideline‖, ―Fire Issues‖ etc. After detailed search on publications regarding fire safety of workers in residential building, the selection criteria of paper is identified to meet the topic or purpose of this thesis.

2.2. Review of literature

1. ***[Jake Paulse: 1987]:*** Evacuation time is relatively complex and it is more difficult to control and predict than is flow time. Two major components of evacuation time are the time needed for the movement directed to egress or escape and the time taken up by relatively complex behavior that precedes or accompanies egress.

2. ***[Torero, J. L.: 2002]:*** Fire Safety Strategy for a tall building is essentially a function of time. It contains two principle components; egress strategy and building performance. Building performance can be further broken down into structural performance and fire spread mitigation. The evacuation strategy is concerned with defining the time required to safely evacuate all building occupants. Building performance concerns the time that the structure can withstand the effects of the fire and the compartmentation remain in place and functional.

3. ***[A.D. Aluthwala et al. – 2011]:*** As per this literature, Fire safety consists of two major components, namely
    1. Fire resistant construction
    2. Fire fighting in case of occurrence

3. Major design concerns are as follows:
4. Control of ignition
5. Provision of adequate means of escape
6. Detection
7. Control of spread of fire
8. Prevention of structural damage or collapse

4. ***[X. Liu et al. – 2012]:*** As per this literature, high-rise buildings and super high-rise buildings become more and more because of high population density and land price. So it becomes more difficult to put out fires from outside and evacuate. It tends to cause great economical loss and personnel casualty accidents easily. According to determination, owing to air convection, the horizontal velocity of smoke diffusion is 0.3 m/s in the initial stage of fire, when in the violent stage of fire, and it may reach at 3-4m /s. Once a high-rise building with the height of 100m catches fire, smoke will diffuse to the top floor through the vertical shafts in 30 seconds and its velocity is more than 10 times of that in the horizontal direction.

5. ***[C. No, no. 21, 2012]:*** As per this literature, the fire safety management system and inspections must ensure that a fire risk assessment is undertaken and is reviewed and updated regularly as construction proceeds. Liaison should be established with the local fire brigade and an initial site plan should be provided. Thereafter, updated site plans should be available at the entrances to the site for fire brigade use.

6. ***[S. Of and P. Service, 2012]:*** As per this literature, an inspection Fire Safety checklist should be prepared for buildings under construction. The major items in the checklist are elaborated as follows:
   - Provision of dry & wet risers
   - Provision of normal lift/ passenger hoist
   - Provision of electrical supply
   - Provision of fire engine access way
   - Provision of adequate pressure & flow

7. ***[C. Ahbab and T. Celik, 2012]:*** As per this literature, the success of construction projects

is highly dependent on meeting the aim of project and objectives within the specified time and budget. Management plays a big role in construction projects. Most important problems that management faces in the projects are methods of execution, management of workers, equipment, scheduling and money. Delay and cost overrun are two of the important defects in construction industry. These failures can lead to various types of negative affections like disputes between contractor and client, decrease quality of work and health and safety accidents. health and safety accidents, poor quality of work and disputes causes time and cost overrun of project.

8. ***[H. Liu, Y. Wang, S. Sun, and B. Sun, 2012]:*** As per this literature, with the development of urban economy, high-rise buildings and super high-rise buildings become more and more because of high population density and land price. Nowadays in our country high-rise buildings develop into the direction of modernization, maximization and multi-functions, so it becomes more difficult to put out fires from outside and evacuate than one that takes place in ordinary constructions considering the high floors, complex functions and diversified devices. Of course it tends to cause great economical loss and personnel casualty accidents easily.
   - High-rise buildings have three characteristics:
   - Construction structure is complicated (its high height, many floors and podium)
   - Functions are complicated and the population density is high (wide functions including residential building, hotel, office building, store and so on)
   - Combustibles is multiple and fire load is large (much combustible decorative material, such as ceiling from combustible material, wall cloth of plastic, wallpaper, curtain etc.

9. ***[Adam Cowlarda et al. – 2013]:*** As per this literature, with respect to evacuation, is measured in time, predominantly the time required for all occupants to reach the outside of a building. The shorter this time, the safer the building is deemed to be. The height of many modern tall buildings, combined with the limited number of vertical escape routes, extend travel times such that the stairwells must act as the outside. They must be designated a -safe zone, which should guarantee the safety of occupants once reached and allow safe transit to a place of refuge, within or outside the building.

10. ***[J. Xin, C. Huang / Fire Safety Journal 62 (2013) 72–78]:*** As per this literature, According to fire statistics in China, the average fire risk of deaths in residential buildings is 4.95 108 deaths/year m2 , and the average fire risk of directive property loss is 1.36 108 million Yuan (RMB)/year m2 over the past 4 years. However, the above inherent risk values of residential buildings are based on some fire protection measures. If additional fire protection measures or operations are put in place, the inherent fire risks would be further reduced by using the residual multiplier. **In theory, the more fire protection measures provided for any given building, the better the fire safety level is, and the more the fire cost is.**

11. ***[Fire Safety Journal, 2013]:*** As per this literature, the risk analysis and fire management analysis coincides each other. Fire management is incomplete without the risk analysis. Fire risk management involves the steps such as risk management, risk identification, risk analysis, risk evaluation and risk treatment. The treatment starts with identification of the risk. Calculating and identifying the building fire risk involves:defining the target building, identification of fire hazards, design of scenario clusters, estimation of frequencies and estimation of consequences.

12. ***[L. C. Bulletin, S. Access, and H. Operations: 2014]:*** As per this literature, buildings under construction present unique fire hazards that require special attention. Fires can result in major losses and long delays in the completion of the project. Factors that should be considered in a fire prevention and protection program for buildings under construction include:
    - Site Access
    - Incendiaries and Arson
    - Hot-Work Operations
    - Housekeeping
    - Utilities
    - Dispensing of Fuels
    - Storage
    - Fire Protection

13. [E. S. Shirur and D. S. Torgal, 2014]: As per this literature, in construction industry,

increase in complexity of operation the industry become dangerous in comparison of their past decades. There are several techniques adopted for the safety construction in India. Some of the main techniques are:

- Safety Organization
- Periodical Safety Audits
- Safety Related Deficiency Management
- Job Hazard Analysis (JHA)
- Safety Training

14. ***[L. Garis, P. Maxim, L. Thomas et al. – 2015]:*** As per this literature, Fuel, heat, and oxygen must be present in the right proportions for a fire to occur. This is often described as the "fire triangle." The addition of a fourth component, a chemical chain reaction, creates what is called the "fire tetrahedron." Once a fire has started, the resulting chain reaction sustains the fire until at least one of the elements is removed.

15. ***[Model Building- Bye Laws, 2016]:*** This literature is a complete list of the fire security norms stated by the government of India.

16. ***[R. Campbell, 2017]:*** As per this literature, NFPA responded to an estimated average of 3,750 fires in structures under construction each year, Fires in structures under construction were associated with five civilian deaths, fifty-one civilian injuries, and $172 million in direct property injury annually. In structures under construction, cooking equipment was responsible for the largest share of fires (27%), followed by heating equipment and intentionally-set fires, each with 13% of the total.

17. ***[Ida Ayu Indira Dwika Lestari et al. - 2017]:*** As per this literature, there are twelve parameters of fire safety that can be used to assess fire safety in a residential building: danger segregation, vertical opening, sprinkler, fire alarm system, smoke detection, interior finish, smoke control, exit access, evacuation path, corridor or compartment, and emergency response training.

18. ***[Sharma & Mishra: 2017]:*** In case of fires in high-rise buildings the most important issue is safe evacuation of people. Fires in high-rise buildings especially are dangerous

because, unlike in low-rise buildings, evacuation is quite difficult and fire control is complex.

19. ***[Tatiana Poliakova and Marina Grigoryan – 2018]:*** As per this literature, If we briefly summarize the analysis of fires in high-rise buildings, the following circumstances that led to a sad outcome:
    - Insufficient fire resistance of structures and engineering equipment
    - Large internal volumes without separating fire barriers
    - Insufficient number of stairwells (also with a small width of the ladder March)
    - A large number of openings in the floors and walls (partitions) for various need (air conditioning, electricity, etc.)
    - A lot of flammable equipment, furniture and cladding, as well as suspended ceilings

20. ***[Evgeniy Degaev- 2019]:*** As per this literature, Fires in high-rise buildings especially are dangerous because, unlike in low-rise buildings, evacuation is quite difficult and fire control is complex. Fires in high-rise buildings feature rapid vertical development and require elaborate evacuation and rescue schemes. Tragic consequences can result from fires in high-rise buildings when fire and the products of combustion block human escape routes.

21. ***[Mckee, 済無, 2019]:*** As per this literature, precautions against fire at construction site: smoking, waste disposal, open burning, spontaneous ignition, fire watch, cutting and welding, and electrical work

22. ***[Dorota Brzeziriska, 2019]:*** As per this literature, the strategy for evaluation of fire is required to be undertaken by specialists of engineering. The specialists can be member of housekeeping and building management staff, insurance companies covering the fire risk of building and residential building engineers. The detection and alarm systems, fire smoke spread alarms, instruments for suspending fires must be compulsorily installed in every residential building.

23. ***[Venkatesh_Kodur et al: 2019]:*** With rapid development across the globe, fire hazard in buildings have undergone significant transformation in terms of severity and versatility

and have become a growing concern in recent years. In the past two decades (1993-2015), a total of 86.4 million fire incidents have caused more than one million fire deaths.

24. ***[Cheap Lives, Costly Commerce, December, 2019]:*** This literature highlights that cheap building materials are used to construct the residential buildings so as to build them at the minimum costs and earn high profits. The journal depicts the violation of norms while construction of buildings and it justifies the fact that the life of people living in the buildings is of no value to the builders. Their lives are even cheaper than the poor infrastructure material used while construction.

25. ***[RSTV: 2019]:*** National Capital witnessed one of the worst fire tragedies in almost two decades when at least 43 people were killed and several others injured in north Delhi's Anaj Mandi. Initial enquiries point out many glaring negligence's such as **locked escape routes, no fire safety equipment and no fire safety clearance from the authorities**.

26. ***[The Hindu, 2020]:*** As per this literature, it is important to modernize the fire and emergency services in India. According to MHA, the deficiency in the country to fight against the fire accidents is the infrastructure for fire management. The literature highlights the measures to deal with fire incidents that include: Firefighting awareness and training workshops, creating building awareness among all the residents of building and conducting time to time fire safety audit.

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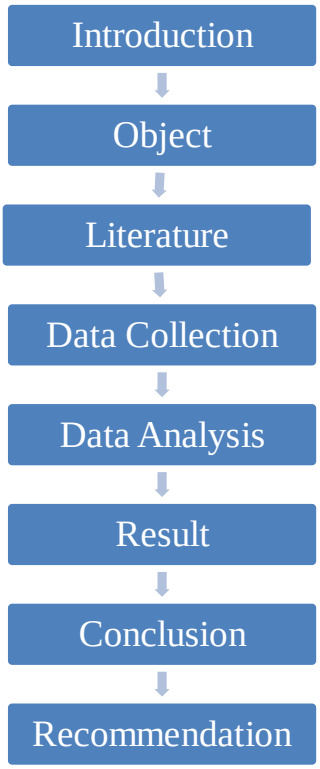
CHAPTER-3

RESEARCH METHODOLOGY

3.1. Introduction

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. In the field of research, the research ―method‖ entails different interventions, strategies, and plans that will be put to use by the researcher to do his or her job. It is like an action plan full of short- and long-term goals. It is also a set of actions—an action plan. Research methodology deals with a range of ways to make for solving key research problems. A methodology offers the theoretical underpinning for understanding which method, set of methods, or [best practice]s can be applied to a specific case to calculate a specific result. The research methodology for **"Evaluation of fire safety norms in residential building"** is as follows:



3.2. Methodology

3.2.1. Review of Literature

Main vision of this phase is to study about various research and theories regarding evaluation of fire safety norms in high rise residential buildings, and identifying the best technique to minimize the evacuation time in high rise buildings.

3.2.2. Definition of study area

In this phase, the study area is identified and also collects all the information regarding the study area. The study area is based on how to decrease the evacuation time in high rise residential building and safely evacuation.

3.2.3. Data collection

In this phase, the data collection conduct by collecting information from a diverse source of documents or electronically stored information. NFPA, National Building Code of India, India Risk Survey, National Crime Records Bureau **(**Ministry of Home Affairs) etc.

3.2.4. Data analysis

In this phase, the analysis of collected data for identifying the method for reducing the evacuation time in high rise residential buildings and also for modification of fire safety norms. This phase also focused on minimizing the spread of smoke to help in the safe evacuation.

3.2.5. Recommendations

In this phase, the additional recommendation for improving the fire safety parameters by focusing on the hierarchy ―prevention is better than protection‖ is taken place.

3.3. References

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CHAPTER-4

DATA COLLECTION

4.1. Introduction

The data collection may conduct by collecting information from a diverse source of documents or electronically stored information. NFPA, National Building Code of Indian, National Crime Records Bureau **(**Ministry of Home Affairs) etc. are the example of common sources of secondary data. This is also referred to as "Data mining".

4.2. Recording number of fires

This survey is conducted the number of fires in building occurred per day. On an average, in India, every year, about 25,000 persons die due to fires and related causes. Female accounts for about 66% of those killed in fire accidents. It is estimated that about 42 females and 21 males die every day in India due to fire.

During the period 2009-2012, Mumbai fire department had attended 13,185 incidents of fire out of which 9711 were caused due to defective electric circuit. The scenario for other major cities is also not different.

According to India Risk Surveys 2018, outbreak of fire poses risks to business continuity and operations and ranks India at 3rd position in fire incidents, especially in Northern and Western regions of India.

A total of 13,099 cases of fire accidents were reported in the country during 2018, showing a decrease of 2.2% during 2018 over 2017 (13,397 cases). 13,099 incidents of fire accidents caused injuries to 777 persons and 12,748 deaths during 2018. The cause-wise analysis of fire accidents revealed that 56.5% of total deaths (7,208 out of 12,748) due to fire accidents were reported in residential buildings during 2018.

Large number of cases of fire accidents were reported in Madhya Pradesh (1,992 out of 13,099), accounting for 15.2% of total such cases during 2018.

Based on a 2011 study, **65%** deficiency was reported in fire stations. According to the (MHA) Ministry of Home Affairs, in **144 towns** with a population over **1 lakh**, there is a huge deficiency of fire fighting infrastructure.

4.3. Common Causes of fire accidents in residential building

- Electrical short-circuit – Faulty electrical system and malfunctioning circuit breakers are one of the leading causes of electrical fires. Or heating equipment in contact with combustible materials like cloth or wood.
- Kitchen fires due to unattended cooking or LPG and microwaves
- Intentional fires like arson
- Careless smoking
- Children playing with matchsticks and candles

4.4. fire safety preventive action-list for high rise Residential buildings

4.4.1. Short-term action list:

- Education and informing (could be performed during fire drills)
- Provide one fire extinguisher in each apartment
- Repair and improvement on installed facilities (house fire hydrants, manual pull stations), periodical checking and regular maintaining
- Installation of sprinkler units at high risk points – kitchens: there is possibility of their connection on existing water-supply system.

4.4.2. Long – term action list:

- Provide prior conditions for constitution a financial support system to able residents for investments and maintains (insurance low)
- Planning and construction of fire escapes for every building to be accessible from each apartment
- Installation of automatic fire alarm system in buildings
- Make revisions to the actual legislation in order to define and standardize procedures inspections and maintaining fire safety building performance and facilities.

4.5. Norm's Violation

The fire related accidents are on hike in residential buildings of the country and the increasing accidents are a cause of worry. It's rightly said that *prevention is better than cure* and government has made many fire related norms as prevention but their

violation is resulting to destructions by fire. “2600 high-rises violated fire safety norms in 4 years”, this is the news headline of a famous newspaper ‘Hindustan Times’ that highlighted the fact that violation of safety norms is responsible for raising fire accidents.

One side the rate of deaths keeps on rising and on the other side the blame game continues. Builder blames the fire extinguisher department for not being on time and poor equipments and fire extinguisher department claims that it is the responsibility of the builder to build them safe, extinguisher cannot be every time everywhere. The government had built the strict norms but their violation is unaccountable. Following are the violations that results to accidents and scary deaths and loss of infrastructure:-

1. In majority of the residential buildings equipments such as fire alarms, smoke alarms and fire extinguishers are not installed resulting which intimation of the fire reaches by the time fire outburst gets out of control.
2. Builder use cheap electrical material for wiring, ventilation, heating, air conditioning resulting short circuits in the residential buildings. The majority of the fire accidents in residential buildings involve shot circuits.
3. Builders do not keep the proper fire exits in the buildings in order to utilize the space and constructing the buildings at minimal cost and this result in violation of fire norms.
4. The norms require proper awareness and training of workers and building staff against fire accidents and guidance to all the residents regarding fire safety norms. But nobody bothers to do the same and the majority of the victims are not able to safe themselves because they do not understand what they should in their protection.
5. Regular risk hazard inspections are not conducted and fire protection equipments are not reinstalled and remain outdated. Occupiers are not concerned regarding regular maintenance.
6. Fire Safety Audit are the key to assess the risks and take corrective actions for the same but the occupants do not conduct the fire safety audit and the risk remains un-assessed. Non-conduct of periodic fire safety inspection raises the chances of fire accidents.
7. Residents living in the building usually exceeds the specified limit under norms.

4.6. References

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CHAPTER-5

DATA ANALYSIS

1.1. Introduction

Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of discovering useful information, suggesting conclusions, and supporting decision making.

1.2. ELECTRICAL FIRES

Electricity is a versatile energy but it has to be safely used. Failure to take precautions against electrical hazards may result in injuries or property damage or both. Control of electrical hazards is neither difficult nor very expensive but ignoring them may lead to serious accident. Investigations of numerous major fires in factories, workshops, offices, hotels, households, high rise buildings and other such occupancies, have revealed that electrical wiring faults are the main sources of fires.

1.2.1. ELECTRICAL FIRES ARE THE RESULT OF

- Design defects and deficiencies in equipments & layout design
- Defects and deficiencies in the protective systems
- Installation defects & improper working conditions
- Improper/poor maintenance
- Deficiencies in testing of electrical equipments
- Natural occurrences such as lightning
- Unsafe operations & misuse

1.2.2. COMMON CAUSES OF ELECTRICALS FIRES

- Short circuit at joints and terminations due to bare wires loosening out of the terminals or wires fraying out and touching other terminals
- Arcing at improper joints, loose connections and terminations resulting in high temperature build-up
- Earth faults in wires with deteriorated insulation
- Overloading
- Heat from other sources

- Sub-standard installation practices

1.2.3. INSTALLATION

- Don’t install electrical power circuits and communication circuits in the same conduit/casing
- Ensure that the wiring for high power consuming devices like air conditioners, geysers, etc, run separately
- Seal cable passes and other opening effectively, using suitable fire protection method such as fire stops and fire breaks. Also go for compartmentation of spaces
- Take extra safety precautions such as reliable termination, use of continuous wire without joints, mechanical protection, thicker insulation and high power rating for wiring in respect of essential services requiring continuous power such as fax machine, computer, communication systems, fire alarm system, etc
- Ensure that the appliances like computers or electronic devices which are sensitive to voltage fluctuations have individual neutrals taken from supply and there is no neutral looping
- Ensure that plug points are away from the places such as sinks, where they are likely and there is no neutral looping
- De-rate the current rating of the wires to ensure that the temperature remains safely within the prescribed limits when a number of wires are laid together in casing or conduit
- Avoid temporary wiring and connections
- Install a master control switch outside occupancies to enable switching off power after office hours
- Have a spare galvanized steel wire in the conduit for pulling a cable in future for additional circuiting or for replacing a defective cable
- Don’t use flexible conduits for general wiring.

1.3. USING L.P.G

Liquefied Petroleum Gas (LPG) stored as a liquid under pressure in cylinders, is widely used in homes as cooking gas. The main hazards associated with LPG are fire or explosion in case of even minor leakage. In case of major leakage in confined

spaces asphyxiation due to deficiency of oxygen may also result. LPG being colorless and odorless, a distinctive foul odder is added to enable easy detection of a leak. As LPG vapor is heavier than air, these vapors accumulate at lower levels and a fire or explosion may result.

1.3.1. SAFE USAGE

- Always keep cylinder in upright position, away from any sources of heat, in a well ventilated place. While moving cylinder, keep it upright
- Don't tilt it to draw the last bit of gas. No extra gas can be obtained by tilting or shaking
- Position stove/burner above the cylinder
- To light the burner, open the cylinder valve, hold a lighted match stick (or gas lighter) over the burner and only then turn the knob of the burner on
- To turn off the burner, first close the cylinder valve and then the burner knob
- When the stove is not in use, keep the cylinder valve closed. Check this particularly every night and whenever you leave the house
- If the flames go out during use, do not relight it immediately. First close the cylinder value and burner knob. Open all doors and windows. Allow time for leaked gas to dissipate. Only then relight the burner
- Do not use synthetic fabric (Nylon, Terylene, etc) while operating the stove. Wear cotton dress
- Keep children away from stove & cylinder
- Use pot-holder when handling pans on the stove. Do not use towels, aprons etc
- Never leave the stove / burner unattended when it is in operation. Cooking materials may overflow on the burners, extinguish the flame and leakage of gas will occur. Accumulated gas could get ignited
- Never try to repair or adjust any part of the gas installation or allow untrained persons to do so
- Do not position shelf/cabinet above the stove
- If your stove is near a window, do not use curtains as they may blow over the burner and catch fire.

1.4. Effective Smoke Extraction

The most important issue in case of fires in high-rise buildings is safe evacuation of people. Fires in high-rise buildings especially are dangerous because, unlike in low-rise buildings, evacuation is quite difficult and fire control is complex.

High-rise building has many staircases, elevator shafts, pipe shafts, air passages, cable shafts and many other vertical shafts. The horizontal velocity of smoke diffusion is 0.3 m/s in the initial stage of fire, when in the violent stage of fire, and it may reach at 3-4m/s. Once a high-rise building with the height of 100m catches fire, smoke will diffuse to the top floor through the vertical shafts in 30 seconds and its velocity is more than 10 times of that in the horizontal direction which make evacuation more complex.

The movement of people in buildings is of two types: normal and forced (in emergencies). Fires in high-rise buildings feature rapid vertical development and require elaborate evacuation and rescue schemes. The direction of human flow must be in the direction of evacuation exits. The high speed of the spread of combustion products leads to the filling of escape routes, and the rapid smoke of the building makes it fatal for people to be in it. In emergencies (fire, in particular), the flow density may reach limits that may result in serious injury or even loss of life.

1.4.1. Fire load

The fire load of a building is a number measured in kilograms-per-square meter. The fire load of a compartment, which can be a building or container, represents the maximum amount of combustible material that is safely stored in that compartment.

$$\text{Fire load} = (W \times C) / A$$

Where,

W = Weight of combustible materials in the compartment (measured in kg)

C = Value of the materials in calories (measured in kj/kg)

A = Area of the compartment (measured in m^2)

1.4.2. Case Study

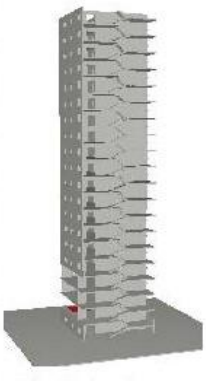


Fig.2: Section view of building

A sample building consisting of 20 floors was created in PyroSim.

Dimensions of each floor including stair case are taken as 12 m x 12 m x 3.25 m.

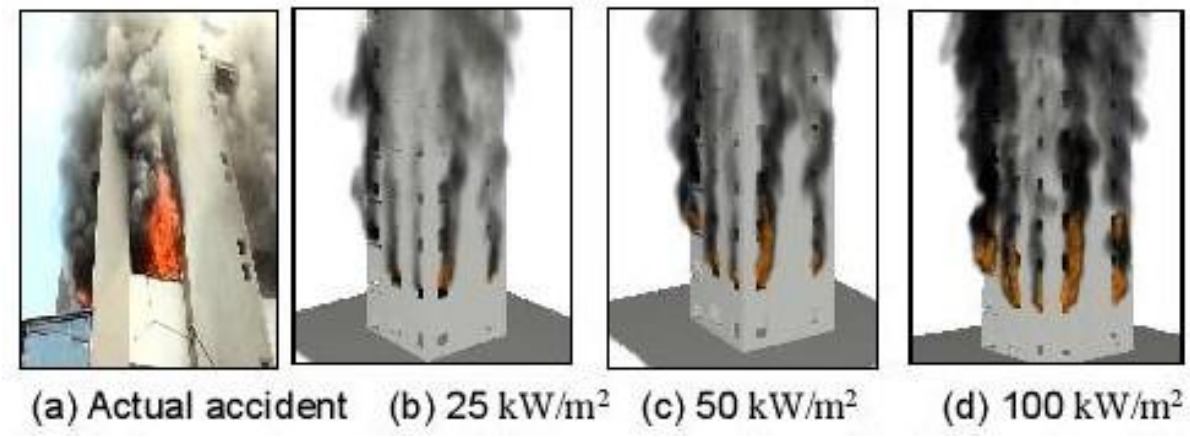


Fig.3: Three different sources of 25 kW/m^2, 50 kW/m^2, and 100 kW/m^2 have been taken for different fire scenarios.

The 50 kW/m^2 case matches with the actual accident.

1.4.3. Fan speed

The optimum capacity of a fan was determined by placing fans at the end and running simulations for different flow rates (2 m^3/s, 5 m^3/s and 10 m^3/s). It was found that 5 m^3/s and 10 m^3/s give better visibility.

Natural ventilation is not sufficient as smoke has filled the stair-case completely and hence need for artificial ventilation arises.

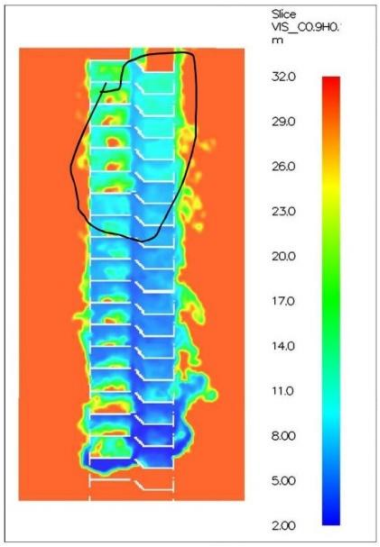
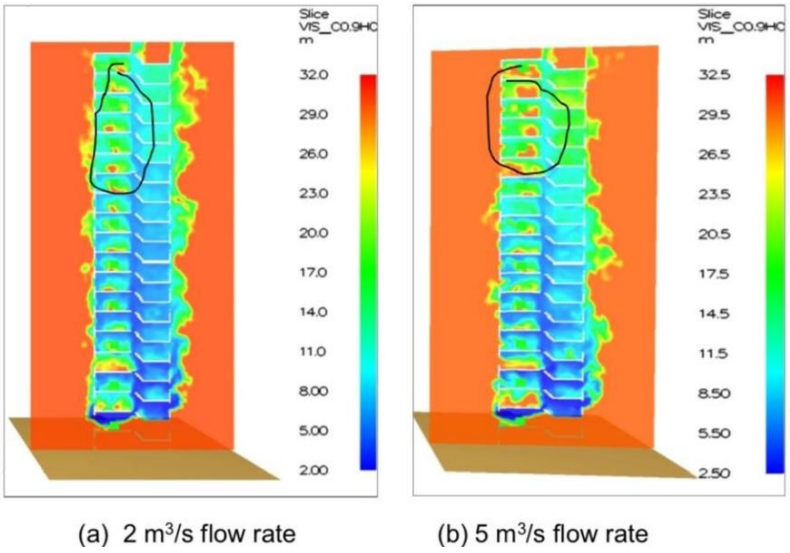


Fig.4: Visibility with No Fan (Natural Ventilation)

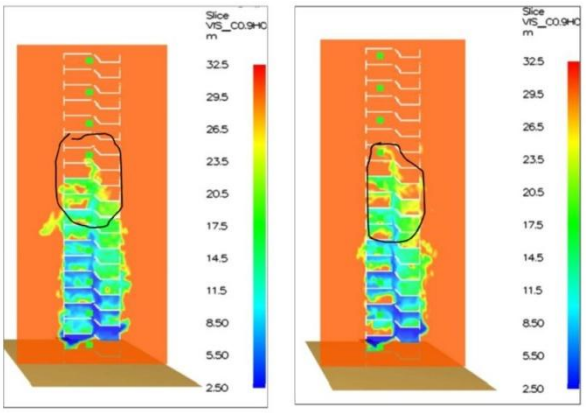


(a) 2 m³/s flow rate (b) 5 m³/s flow rate

Fig.5: Visibility for fans placed at one end on alternative floors at t=500 s

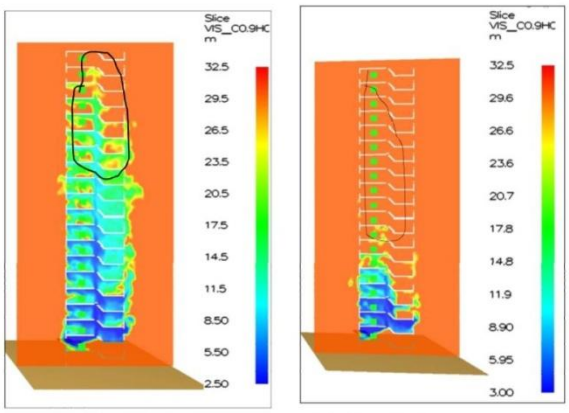
1.4.4. Fans location

First the location of fan on alternate floor is decided. Placing fans at end (opposite to the main door) has more visibility. It was found that the visibility is maximum in the case when fans are placed on each floor.



(a) 10 m³/s fans at center (b) 10 m³/s fans at end

Fig.6: Visibility for fans placed on alternative floors at t=500s



(a) 5 m³/s flow rate (b) 10 m³/s flow rate

Fig.7: Visibility for fans placed at end on each floor at t=500s

By considering 10 occupants on each floor showed that 300s are needed to completely evacuate the building. Tragic consequences can result from fires in high-rise buildings when fire and the products of combustion block human escape routes. Fire proof doors / Fire rated doors to be provided in the entrance to emergency staircase. So ½ hr to 1 hr time people will get to escape after starting fire, as fire rated doors are fit for standing intact 30 min to 60 min.

1.4.5. Visibility Analysis

It can be seen from that fans on each floors have high visibility compared to fans on alternative floors. Visibility follows a linear relationship with the flow rates of fans. For a particular floor, it increases almost linearly with the increase in flow rate.

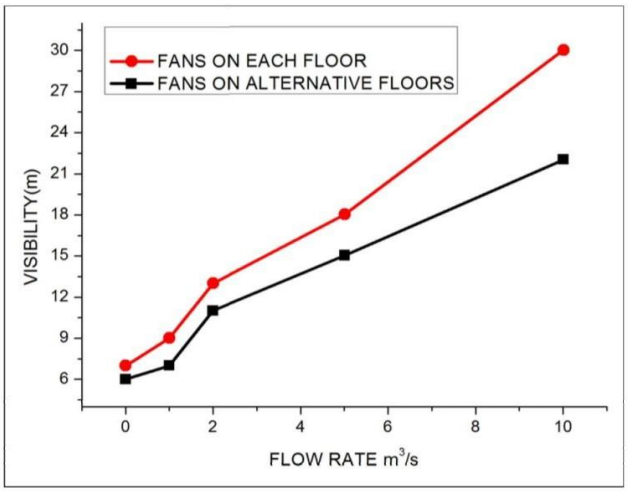


Fig.8: Visibility Analysis

1.5. Safe evacuation

A holistic Fire Safety Strategy for a tall building is essentially a function of time. It contains two principle components; egress strategy and building performance. Building performance can be further broken down into structural performance and fire spread mitigation e.g. compartmentation. The evacuation strategy is concerned with defining the time required to safely evacuate all building occupants. Building performance concerns the time that the structure can withstand the effects of the fire and the compartmentation remain in place and functional. Safety, with respect to evacuation, is measured in time, predominantly the time required for all occupants to reach the outside of a building. The shorter this time, the safer the building is deemed to be.

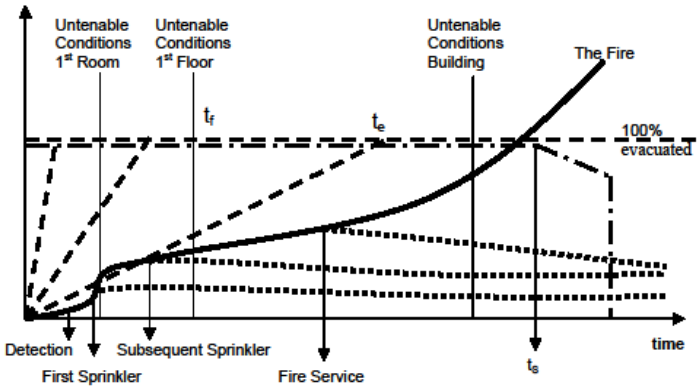


Fig.9: Safe Evacuation

Schematic of the sequence of events following the onset of a fire in a multiple story building, the thick line corresponds to the "fire size," the dotted lines to the possible outcome of the different forms of intervention (sprinkler activation, fire service). The dashed lines are the percentage of people evacuated, with the ultimate goal of 100% represented by a horizontal dashed line. The dashed & dotted line corresponds to the percentage of the full structural integrity of the building.

It represents the behavior of a building in the event of a fire. It could be argued that the safety objective should be that the time to evacuation (t_e) at each compartment (i.e. room of origin, floor, and building) be much smaller that time necessary to reach untenable conditions in the particular compartment (t_f). Characteristic values of t_e and t_f can be established for different levels of containment, room of origin, floor, and building. Furthermore, it is necessary for the evacuation time to be much smaller than the time when structural integrity starts to be compromised (t_s).

In summary:

$$t_e << t_f$$

$$t_e << t_s$$

It could be added to these goals that full structural collapse is an undesirable event, therefore:

$$t_s \rightarrow \infty$$

Although these criteria for safety times can be considered as a simplified statement, it is clear that it describes well the main goals of fire protection.

With the objective of achieving these goals a number of safety strategies are put in place. These include those strategies that are meant to increase t_f which include active systems, such as sprinklers, or the intervention of the fire service. As shown in Figure (dotted lines), success of these strategies can result in control or suppression of the fire. Passive protection such as thermal insulation of structural elements becomes part of the design with the purpose of increasing t_s. Finally, but most important, evacuation protocols and routes are design to minimize t_e at all stages of the building. It is important to note that within the estimation of t_e the safe operations of the firemen need to be included.

1.5.1. Flow Time

The total time needed for crowd movement to occur or the total time taken for people to move past or through one part of a circulation system is termed as flow time.

1.5.2. Evacuation Time

The total movement time taken to go from a point of origin to some destination such as a remote place of safety is termed as evacuation time.

1.5.3. Total Evacuation Time

The term "total evacuation time" will be used in cases where all occupants are evacuated, either in a controlled fashion or in an uncontrolled fashion.

Evacuation time is relatively complex and it is more difficult to control and predict than is flow time. Two major components of evacuation time are the time needed for the movement directed to egress or escape and the time taken up by relatively complex behavior that precedes or accompanies egress.

There are four sub-components of evacuation time, the first two sub-components of evacuation time are relatively simple and they are usually the only components directly affected by the means of egress requirements. The subcomponents are:

1) The flow times through the various flow elements of the egress system, especially the least efficient element with the longest flow time
2) The travel time for some individual in the evacuating crowd to move along the most direct egress route.

Even less simple, and requiring extensive information and judgment to predict well, are the third and fourth sub-components which may be quite substantial and generally should not be ignored

3) The pre-movement time between the onset of the cue or condition that is supposed to initiate an evacuation response and the decision by each evacuee to begin moving, not necessarily directly to an exit
4) The time component due to any behavior that diverts an individual from the most direct egress route once that person's egress movement is initiated. (For example, in fires, people's first actions are often not simply to evacuate but to seek information, inform others, assist others, fight the fire, etc.)

1.5.4. Equation for Total Evacuation Time

$$\text{Evacuation Time } (t_e) = \text{Flow Time} + \text{Travel Time}$$

1.5.4.1. Flow Time

Flow Time is obtained by dividing the Population (Na) by the Flow Capacity which is the width of the most limiting passageway (B') multiplied by the mean flow capacity of that passageway (N').

$$\text{Flow Time} = \frac{\text{Population (Na)}}{\text{Flow Capacity (B')(N')}}$$

1.5.4.2. Travel Time

Travel time is obtained by the first person in the evacuating crowd who moves from a point of origin to the destination where his or her evacuation is considered complete; i.e., the travel distance (k_a) divided by speed of movement (v).

$$\text{Travel Time} = \frac{\text{Travel distance (ka)}}{\text{Speed of movement } (v)}$$

1.5.4.3. Total Evacuation Time

$$\text{Evacuation Time (Te)} = \frac{\text{(Na)}}{\text{(B')(N')}} + \frac{\text{(ka)}}{(v)}$$

Buildings must be designed so that occupants can escape safely if a fire breaks out. They must be able to reach a place of safety without being overcome by heat or smoke, and so the time taken to escape needs to be shorter than the likely time it will take for fire or smoke to spread.

This can be achieved by controlling fire spread and by ensuring that escape routes are easily accessible and neither too long nor too complex.

1.5.5. Movement on stairs

The time that it takes an occupant population to reach safety when descending a stair during building evacuations, previously researchers have collected evacuation time from a variety of buildings under different emergency and non-emergency conditions. In order to calculate

evacuation time of a particular building, researchers have collected three different types of people movement data during evacuation. The most common type of data is movement speed. Movement speed has been reported in terms of distance per unit time (m/s). The data collected from three different ways; actual fire events, evacuation drills, and normal conditions.

Table.1: Actual fire event

S.No.	Data collection method	Sample size	Movement speed	Stairwell Detail
1	Telephone interview	368	0.20 m/s	1100 mm-wide stair
2	Interview	254	0.29 m/s	1400 mm-wide stair

Table.2: Fire Drills

S.No.	Data collection method	Sample size	Movement speed	Stairwell Detail
1	Announced drill	910	0.71 m/s	1190 mm-wide stair
2	Fire drill	1191	0.66 m/s	1100 mm-wide stair

Table.3: Normal condition

S.No.	Data collection method	Sample size	Movement speed	Stairwell Detail
1	Video recording	1000	0.87 m/s	1200 mm-wide stair
2	Video recording	1000	0.98 m/s	1000 mm-wide stair

Table.4: The movement of people under normal conditions is divided into three age groups

S.No.	-	Men			Women		
1	Age	Under 30	30 to 50	Above 50	Under 30	30 to 50	Above 50
2	Movement speed	0.98 m/s	0.81 m/s	0.67 m/s	0.70 m/s	0.60 m/s	0.56 m/s

1.5.6. Stairs Design

Stairs are used to create a pedestrian route between different vertical levels by dividing the height between the levels into manageable steps. Very generally, the word 'stairs' refers to a staircase, whereas the word 'step' refers to the individual steps that make up the staircase.

Switchback Stairs

Switchback Stairs are essentially two parallel flights of straight stairs joined by a landing that creates a 180° turn in the walk line. Switchback Staircases turn 180°, either via one landing or two. When a Switchback Staircase requires two landings (usually referred to as quarter landings) to complete the 180° turn, it is usually then called a U-Shaped or Half Turn Staircase.

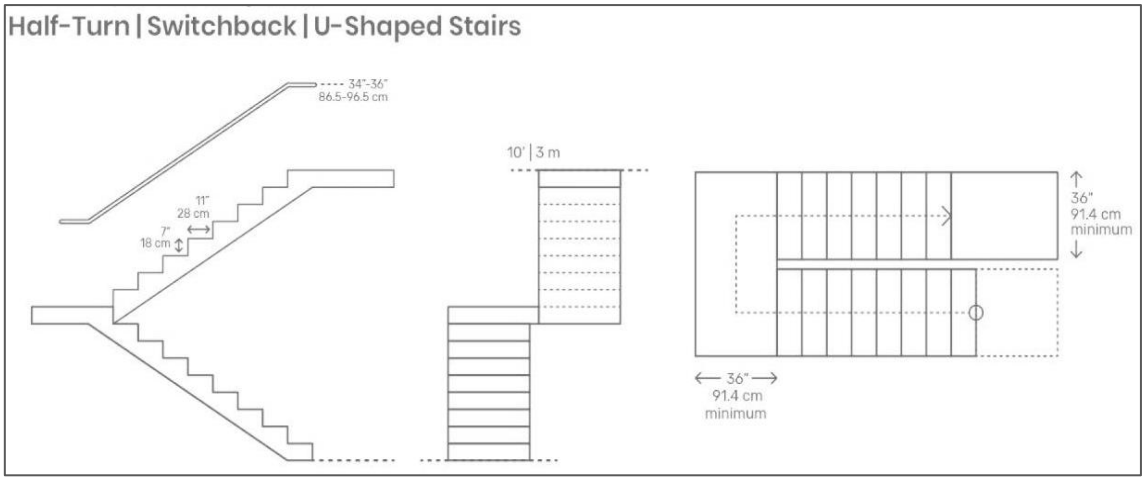


Fig.10: Switchback Staircases

Spiral Stairs

Much like Curved Staircases, Spiral Staircases make complete turns without the interruption of landing platforms. However, spiral stairs actually make a full circle which is 360°.

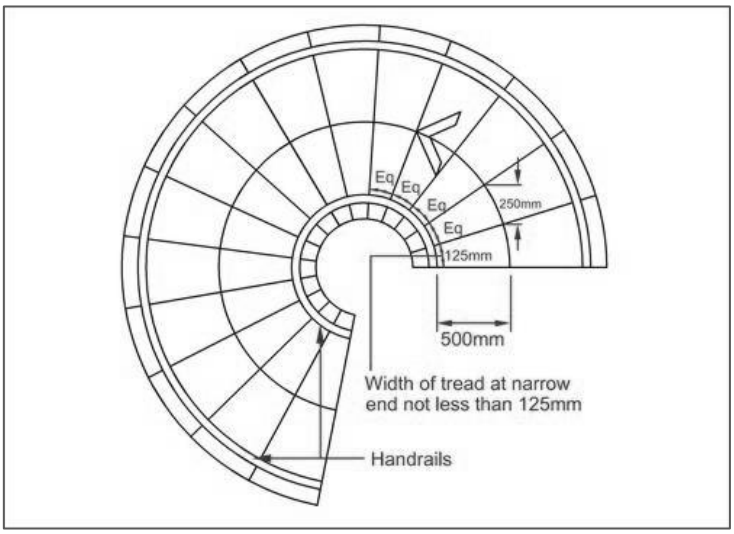


Fig.11: Spiral Staircases

Velocity (v) in linear movement in Switchback Stairs will be same as angular velocity (ω) in Curved Stairs

i.e., $v \sim \omega$

v_1 (for linear movement) $\sim \omega$

v_2 (for circular movement) = $r\omega$

$v_2 \propto r\omega$

$\therefore \quad v_2 \propto r$

i.e. $v_2 > v_1$ (r should be greater than 1)

Hence, movement in circular stairs will be easier and convenient as the radius factor (r) plays direct role in its velocity.

Hence proved $v_2 > v_1$

So the formula for total evacuation for spiral stairs is

$$\text{Evacuation Time (Te)} = \frac{(\text{Na})}{(\text{B}')(\text{N}')} + \frac{(\text{ka})}{(r\omega)}$$

CHAPTER-6

CONCLUSION

6.1. Conclusion

Larger and devastating fires took places in numerous high rise building causing loss of life and property. It is difficult to fight a high rise building fire as it quickly spreads upwards (due to Chimney Effect) and the external fire fighting appliances may not be able to reach higher floors. Evacuating people especially invalids, old persons and children, without panic poses practical difficulty in most case. High-rise buildings and super high-rise buildings become more and more because of high population density and land price. Increase in number of high-rise building, fire accidents also increases as well. Evacuation is quite difficult and fire control is complex as the number of floors increases in high-rise building.

- Heavy usage of electrical appliances should be avoided and good quality materials should be used.
- Loads in electrical wiring should be provided with a margin to avoid short-circuit in future on increasing electric load.
- Keeping in mind the thought "Prevention is better than protection" in every part of safety steps.
- The passage should be very clear and easily available at important part of building.
- Emergency exits should have a proper and planned movement.
- Shaft or OTS should be provided near the emergency exit or stairs.
- There should be proper ventilation for good visibility which can obtain by using good exhaust at the ventilation.
- Spiral stairs can be used to make easy movement across the floors in the building.
- Spiral stairs can have much easier movement as compared to normal stairs as they create higher velocity by having good angular velocity.
- Circular movement creates angular velocity which on multiplying with radius according to area gives good linear velocity that's what needed for quick passage.

Flowing safe practices in respect of electrical wiring would help to reduce fire incidents

- Prefer copper wiring / cables

- Use only ISI marked wiring/cables and related accessories
- Don’t use 1sq.mm cable at all in the household
- Use 10 Sq.mm cable for main connection between the electricity supply meter and the main switch on the distribution board in the house/flat and 6 mm cable for connection between distribution board and sub distribution board in each floor
- Use 4 sq.mm cables for supplies to geysers, heaters and Air conditioners and such heavy loads and 2.5 sq.mm cable for supplies to TV kitchen appliances, refrigerator, washing machine, dish washer and electric iron.

Build employee awareness and training programs

Prevention is only effective when all individuals play a role. If one employee creates or doesn’t report a fire hazard, all other prevention strategies may be ineffective. By building awareness and training employees on proper fire prevention procedures, organizations ensure they will be followed at all times. This lowers the risk of any fire-related incidents.

CHAPTER-7

RECOMANDATION

7.1. Electrical Fault

7.1.1. SPECIAL REQUIREMENTS FOR HIGH-RISE BUILDINGS

- Employ special insulating materials such as FRLS (Fire Retardant Low Smoke) for wiring/cabling meant for fire alarm systems, emergency lighting, computer installations and such equipment whose uninterrupted performance in fire situations is essential
- Provide separate circuits for firefighting pumps, lifts, staircases and corridor lighting and blowers for pressurizing system, directly from the main switch gear panel. Use separate conduits for such circuits
- Label clearly the masters switches controlling essential services
- Lay electrical distribution cables/wiring in a separate duct. Seal the duct at every floor with non-combustible materials having the same fire resistance as that of the duct
- Don't lay water mains, Telephone lines, inter-com lines, gas pipes and any other services line in the duct meant for electrical cables
- Use separate metal conduits for medium and low voltage wiring meant for lighting or other services, above false ceiling
- Provide suitable circuit breakers at the appropriate points
- Use brass or copper for bonding and earthing. Use non-rusting bolts in damp situations

7.1.2. TESTING

- Check integrity of insulation at regular intervals
- Conduct insulation resistance test at least once in a year and when any addition or alteration is carried out in the installation

Ensure that all electrical wiring and repair jobs including additions, alterations and repairs to the existing installations are carried out by licensed contractors as per the Indian electricity Rules, 1956.

7.2. USING L.P.G SAFELY

7.2.1. SAFETY WHILE TAKING DOOR DELIVERY

- Check whether valve sealing tag is intact and safety protection cap is in position
- Check leakage from valve by applying soap solution.

7.2.2. SAFETY WHILE CHANGING CYLINDERS

- Put out all fires in the room
- Switch off all electric appliances
- Check for leakage from the rubber tube connections by applying soap solution
- Never light a matchstick to check the leakage
- Leave changing of new cylinder to trained persons
- Don't drag, roll or drop the cylinder
- Open the windows for free ventilation
- Preserve safety protection cap.

7.2.3. IN CASE YOU SUSPECT LPG LEAKAGE

- Close burner knobs and cylinder valves and re-fix safety protection cap
- Extinguish any open flames
- Don't light a match or bring in other ignited material
- Open windows for free ventilation
- Do not touch electrical switches
- Do not tamper with the installation
- Immediately contact your distributor and the Fire brigade. Keep their phone nos. handy.

7.3. WATER TANK

As per the national building code, not to keep a separate water tank for storing water in the roof of the building for fire fighting. There should be two water tanks on the roof with a common wall. Water pumping to the roof tank will first come to the fire water storage tank and overflow only will go to the raw water tank. So there will always be sufficient water in the tank to fight the fire.

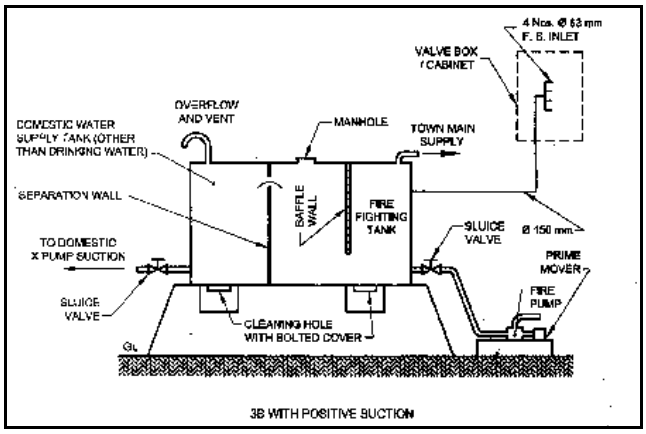


Fig: 12 Water tank

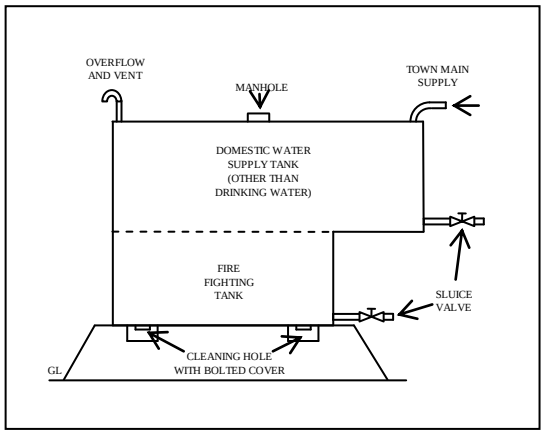


Fig: 13 Modified Water Tank

7.3.1. Modification in water tank

As per modification, not to separate a water tank with a common wall for storing water on the roof of the building for fire fighting

There should be only one water tank on the roof that separates the water tank horizontally. Water pumping to the roof tank will first fill the fire fighting tank and after filling the fire fighting tank the water fills the domestic water supply tank. So in case of fire, there will always be sufficient water in the tank to fight the fire i.e. fire fighting water + domestic water.

7.4. USE OF SLIDE ON SPIRAL STAIRS

Evacuating high-rise buildings during emergencies has been a problem since the architect started designing them.

When a high-rise building catches up fire then it's become difficult to escape. A special emergency slide should be installed inside the spiral staircase from the top floor to the ground; the slide should be 50cm wide and made up of the thermosetting polymer. The slide can allow nearly about a hundred people to evacuate a building at a time; it is observed that, using a protection pad it took only 90 seconds to slide down from the 25th floor of the building to the ground.